CONNECTICUT SHORELINE SURVEY

NEW HAVEN TO WATCH HILL

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Final Report

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PREFACE

The objective of this brief survey of the coastline is primarily to identify areas of pronounced erosion or deposition, and to collate information on its surficial geology. The report is based on previous work conducted by government and university researchers, USGS map publications and current revisions, unpublished data and spot checks in the field.

The attempt is made to put the coastal geology into perspective by a general treatment of large scale features, and coastal processes, followed by a more detailed discussion of certain small scale shoreline features.

The study is limited in detail by the time and facilities allotted for it, the size of the study area and the detail of previous treatments.

Several people were helpful in locating sources of information and through discussions of Connecticut geology. My special thanks go to Mr. Jared Wibberly, Dr. Jelle DeBoer, Dr. Joe Webb Peoples and Mr. Sidney Quarrier.

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INTRODUCTION

General Geology

The present coastal configuration of Connecticut is the product of geologically recent marine intersection and modification of older structures and deposits. Three well accepted concepts are fundamental to its geology: a) a pre-cretaceous eroded *bedrock* surface determines most large scale and many small scale aspects of the coast including its general E-W trend and its drainage pattern; b) the overall origin and distribution of sediments is largely the result of a period of *glaciation* which "ended" about 10,000 years ago; and c) subsequent to the glaciation, *sea level* has been rising.

Bedrock

The bedrock surface of the Connecticut coast, the so called Fall Zone surface (9) has a general E-W strike and dips south at about 50 ft./mile (10, 11). Bedrock valleys were carved into the Fall Zone surface prior to the Pleistocene glaciation, which started a couple of million years ago. In the study area, the largest and best defined bedrock valleys underlie the major rivers, the Quinnipiac, Connecticut and Thames River. They are best defined because most data came from bridge borings (29). Cross sections shown in Figure 1 indicate that near the present coast the thalweg of the Thames River lies at least 174 ft. below sea level and those of the Connecticut and Quinnipiac Rivers are deeper than

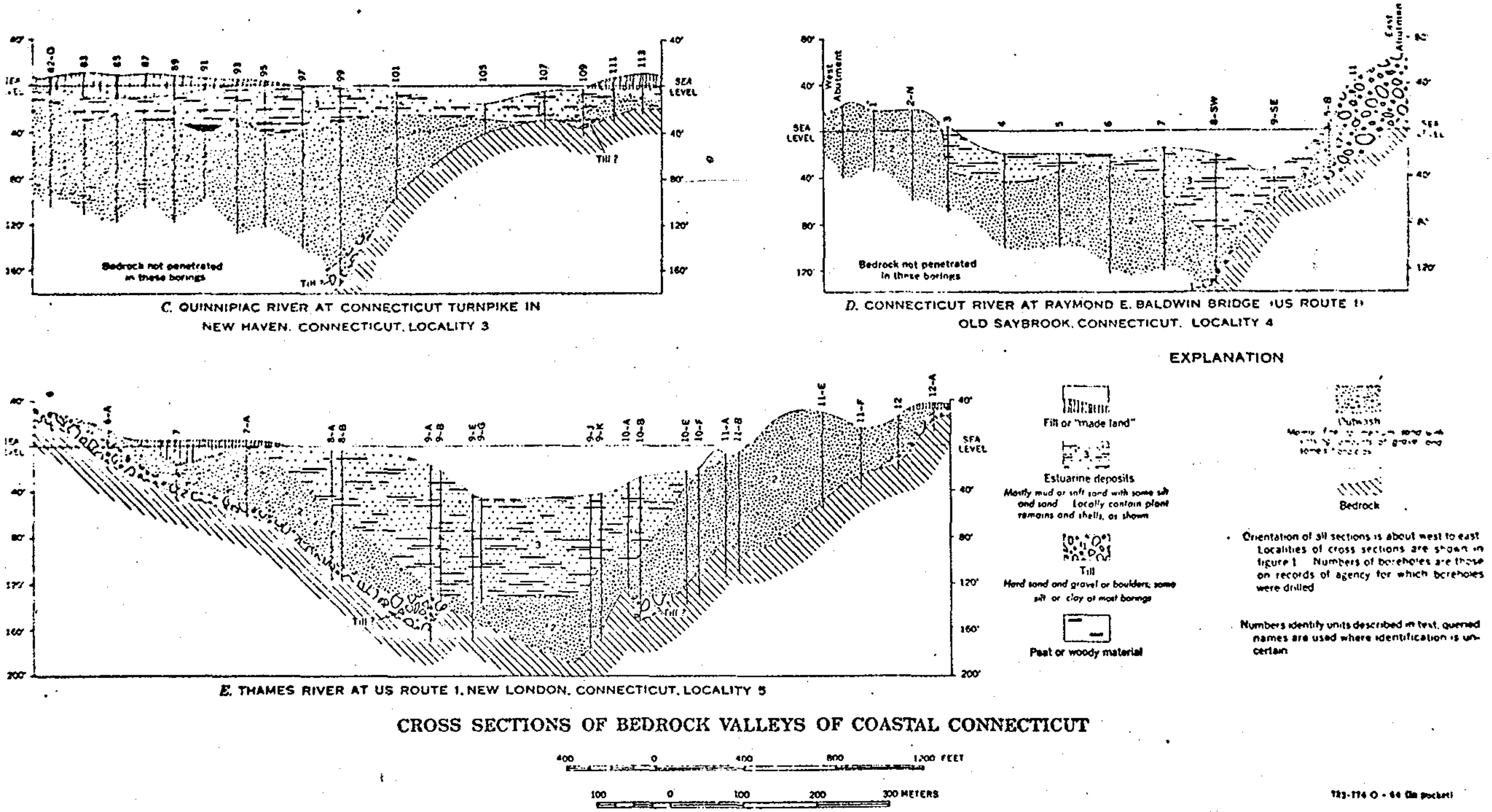


Figure 1. Cross sections of certain bedrock valleys of coastal Connecticut (from Upson & Spencer, 1964;29).

140 and 200 ft. respectively. It is estimated that the valley beneath the Quinnipiac may exceed 280 ft. depth (29).

Other bedrock valleys are poorly defined. In Mystic (Mystic Quadrangle) a test well south of the railroad bridge penetrated 110 ft. below sea level without encountering bedrock (28) and in the West River Valley (Guilford Quadrangle), south of the turnpike, bedrock was first encountered at a depth of about 75 ft. below sea level (12). Seismic reflection work in Long Island Sound (15) shows a major valley extending from the Clinton Harbor area.

Where bedrock outcrops on the shore it forms highly resistant structures which have not eroded appreciably in many centuries. Their resistance to erosion (and the relatively low intensity of coastal erosion) is indicated by the lack of wave formed bedrock cliffs and the persistence of glacially carved whaleback forms preserved in coastal outcrops (26).

Glaciation

Although preexisting sediments and weathered rock were removed, erosional influences by glaciation had a minor effect on the bedrock topography (25). In certain locations, however, preexisting valleys were over deepening by up to 100 ft. (25). On the other hand, glacial deposition has a strong influence on the coast and accounts for major features. In places, the independence in distribution of glacial deposits from bedrock topography control implies deposition by relatively thick ice (12). Figure 2 summarizes the distribution of end moraines over most of the study area. The prominent Charlestown-Harbor Hill moraine is responsible for deposits at Watch Hill Point and Napatree Point but otherwise is important mainly through the protection it and the more southerly moraine offer the Connecticut coast. Other end moraines, which intersect the coast at a slight angle, account for prominent features at the mouth of the Connecticut River and at Clinton Harbor. Additional moraine deposits, classified as till on the surficial geology maps, will probably be delineated.

Drumlins and N-S elongate till deposits occur along the coastline as resistant headlands, such as Black Point (Niantic Quadrangle) and Bluff Point (New London Quadrangle) or as eroded cliffs such as along the eastern Old Lyme shore. Prior to widespread artificial stabilization, these deposits probably provided most of the sediment incorporated in beach features along the coast. Outwash deposits were also significant in this regard.

Sea Level

The rise of sea level since late glacial times from a low stand of about -300 ft. is well documented (27). Its transgression in New England is indicated by drowned beach features (20) and by offshore peat (8) and estuarine deposits (21). The rise is also recorded in coastal estuarine and marsh sediments (2, 23).

From his study in Clinton marsh Bloom determined the rate of sea level rise for the past 7,000 years. The data suggests a

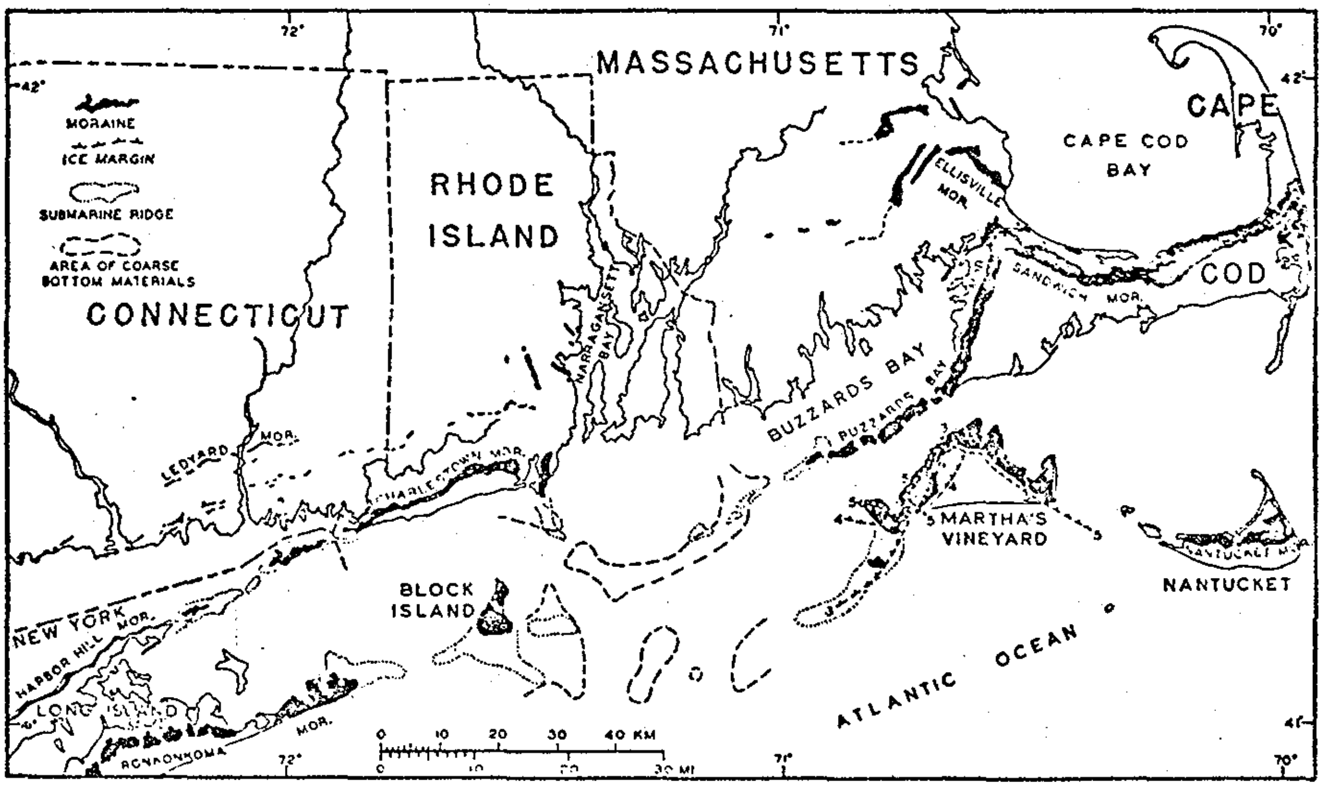


Figure 5. Distribution of end moraines in southern New England (from Schafer & Hartshorn, 1965;25).

discontinuity at about 3000 BP when the rate decreased from about 0.6 ft./100 yrs. to about 0.3 ft./100 yrs. (2). At present on the basis of tide gauge records the rate appears to have increased to more than 1 ft./100 yrs. but whether this represents a long term trend is not known (17).

A rising sea level (or submerging coast) is, of course, associated with a transgression of the shoreline. Figure 3 illustrates the relationship between slope and transgression for reasonable limits for rate of sea level rise. As discussed by Bloom (5), however, submergence alone does not determine the position of the shoreline since in the real world the processes of erosion and deposition take an appreciable period of time relative to rates of submergence. In Long Island Sound the incompleteness of such erosion and deposition are indicated by drowned reefs and irregular deposits of till (e.g. Hatchett Reef). The shoreline owing to submergence alone is best indicated by the landward boundary of salt marshes, backwaters and lagoons. Coastal processes which produce the "final" shoreline form include reduction of headlands, growth and landward movement of barrier spits (7), and filling of backwaters and estuaries by "up stream" or landward movement of bottom sediments (16). Over geologically short periods of time these processes are incomplete and salt marsh filled backwaters can become a prominent feature.

In the study area the extent of filling of estuaries by coastal sediments is appreciable even compared with glacial deposits

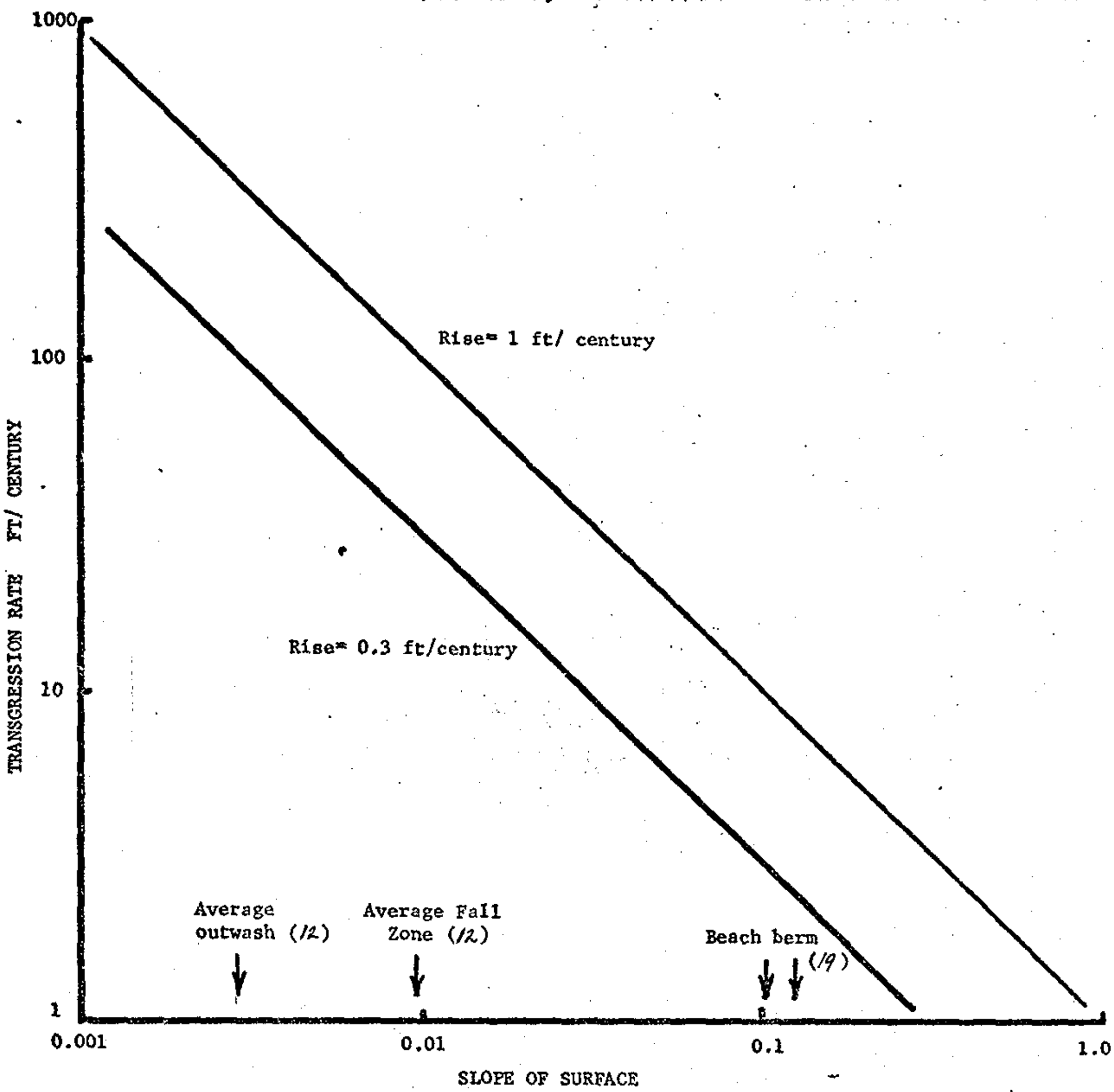


Figure 3. Calculated relationship between transgression rate of the shoreline and slope of the underlying surface for reasonable long term rates of sea level rise. Representative average slopes for Connecticut outwash surfaces, the Fall Zone surface and beach berms are indicated.

(Figure 1). Studies by Bloom and others show that estuarine and/or salt marsh sediments are widespread and up to about 40 ft. thick along the coast (4, 18).

As in most heavily populated regions, man's activities along the coast have been to retard the processes which yield an equilibrium coastal form: seawalls protect headlands, groins slow spit growth, dredging reverses harbor filling. That an increasing proportion of coastal erosion damage is incurred by coastal defense structures themselves (exceeding 50% of the total estimated damage) (48) is in part an indication of the persistence and intensity of these processes.

The importance of relatively rapid submergence to historical coastal modification can be great, and on outwash deposits in Connecticut theoretically might have caused up to 300 ft. of transgression in a century (Figure 3). However, appreciable coastal recession is primarily associated with severe storms and there is little question that even if sea level were presently dropping 1 ft./century hurricanes of the 1938 and 1954 intensity (which accompanied tides 10-13 ft. above normal) would cause severe damage for centuries to come.

Previous Coastal Surveys

The classical work on the Connecticut shoreline is that of Sharp done in 1929 (26). His discussion of coastal processes is of limited use, however, because he did not recognize the role of rising sea level and often did not include time estimates in his treatment of erosion.

Bloom's studies of the Connecticut coast include much detailed and general information and provide good insights into coastal geology of the area. He subdivided the coast into 7 subdivisions based on the relative prevalence of glacial drift, rock, beaches and marsh (6). Figure 4, reduced from his 1:250,000 scale map, summarizes this and other information. The map was generalized from 1:24,000 scale maps prepared by close field inspection of the entire coast (6), but the detailed information has never been published (Bloom, personal communication).

The Beach Erosion Board studies prepared in cooperation with the State of Connecticut (30 - 36) are complete for the entire coast. A summary of subsequent beach nourishment projects and behavior of the fill is given by McCabe (19).

The study area is included in the National Shoreline Study (38) which identifies the ownership, use and condition of erosion along the shore and presents general management plans for its future use and protection. In Figure 5 shoreline erosion is classified as "critical" or "non-critical". Included in the 25 miles of "Critical Erosion Areas" are about 20 miles "which consist of inadequate beaches". Apparently, therefore, the classification should be construed as a special term for management, rather than purely geological purposes.

The marsh study of Hill and Shearin (18) includes all marshes larger than 15 acres and presents a scheme of soil classification

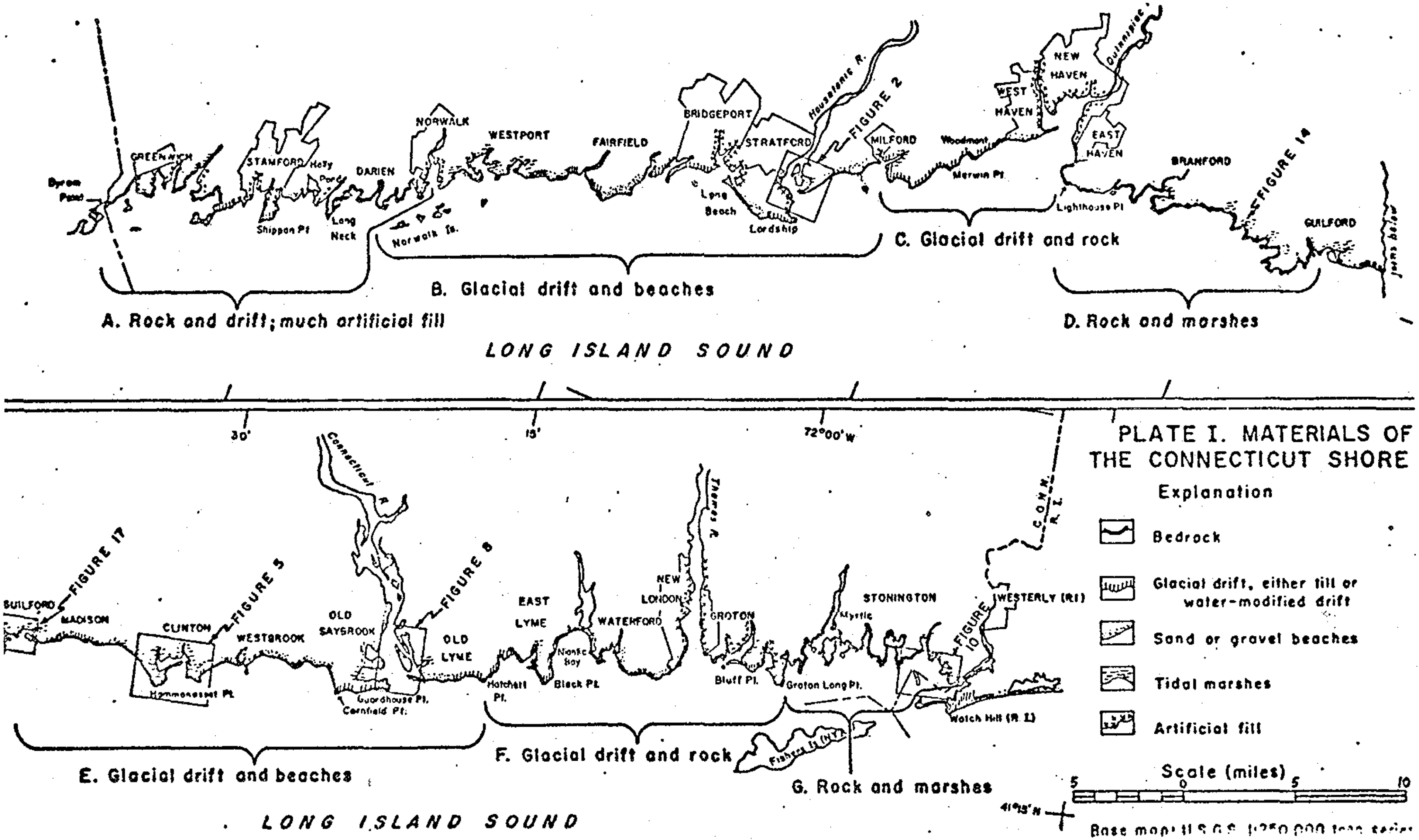


Figure 4. Subdivision of the Connecticut shoreline according to prevalent shore materials according to A.L. Bloom (from Bloom, 1967; 6).

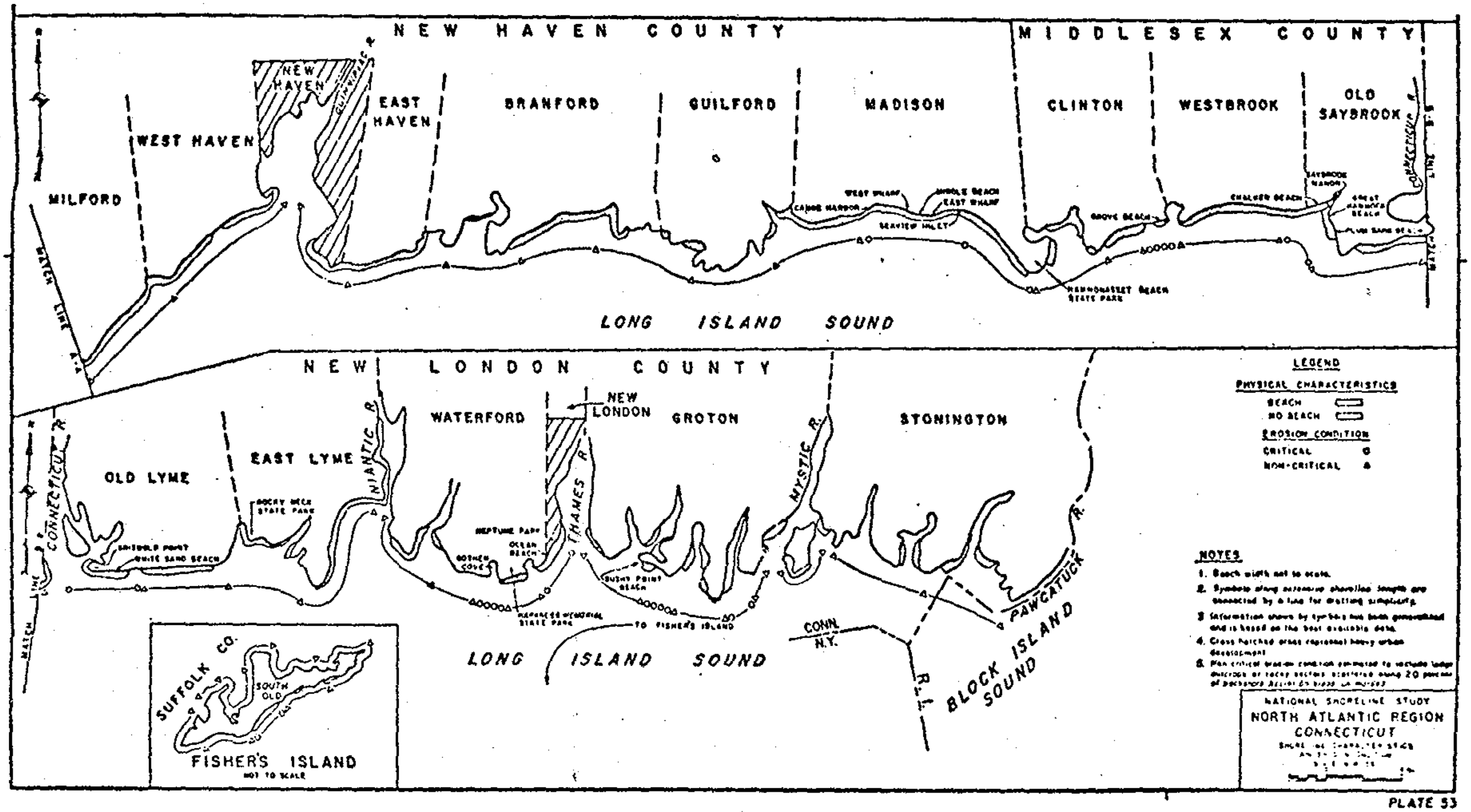


Figure 5. The National Shoreline Study erosional classification of the shoreline from Merwin Point to Watch Hill Point (from U.S. Army Corps of Engineers, 1971; 38).

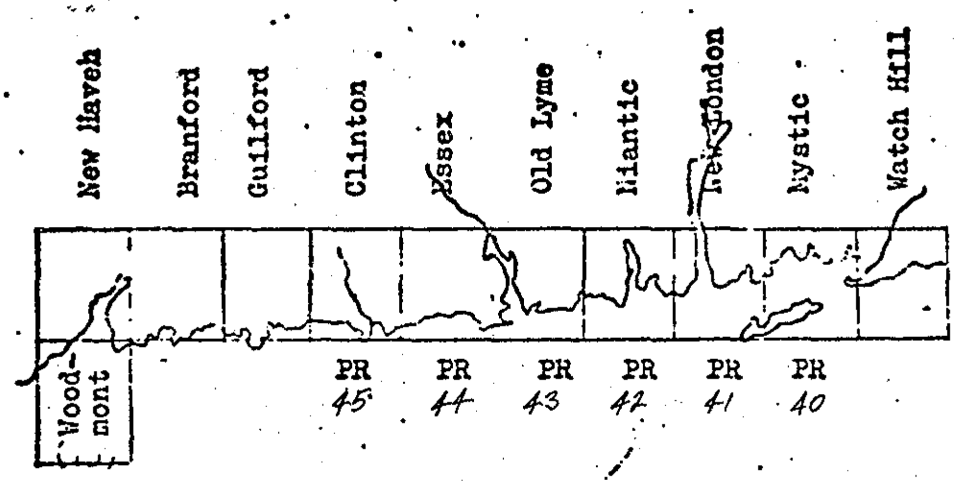
based on a study of cores. The lack of distinction between marsh and underlying estuarine sediments makes their designation of deep versus shallow "marshes" less useful than it could be. In this regard the data they present and that of Bloom (4) is most useful.

A study conducted as part of the Long Island Sound Regional Study, directed by the New England Regional Commission, is classifying the shoreline according to many characteristics of interest. Table 1 gives part of the outline of their study, which is not yet completed.

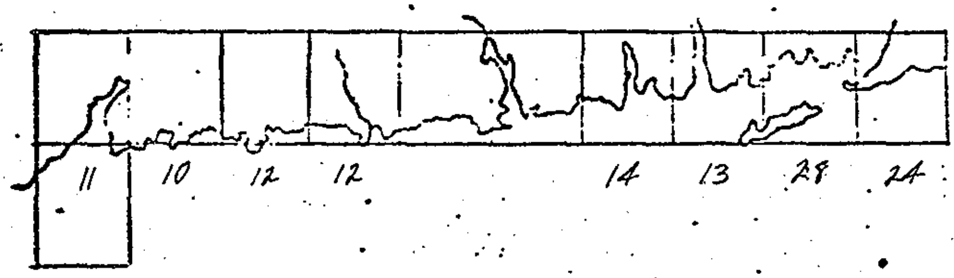
The coverage of certain applicable government publications is indicated in Figure 6.

Table 1. Shoreline description and classification scheme of Work Group I-3, Long Island Sound Regional Study, New England River Basins Commission (Beals, personal communication). Report under prep-

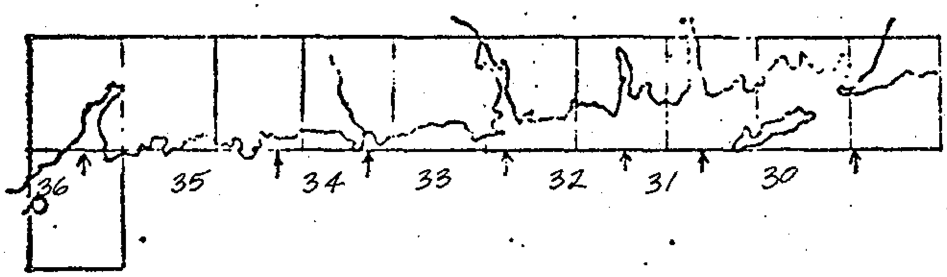
Classification Number	Description
	I. Shoreline
	A. Landform
	1. Beach
	a. texture
1	(1) sand
2	(2) gravel
3	(3) cobble
4	(4) boulders
	b. width
5	(1) narrow
6	(2) average
7	(3) wide
	2. Rocky Shore
8	a. narrow
9	b. average
10	c. wide
	3. Marsh
11	a. narrow
12	b. average
13	c. wide
14	4. Bluff
15	5. Inlet
	B. Vegetative Cover
16	1. Trees
17	2. Grass
18	3. Shrubs
	C. Structural Cover
	1. Buildings
	a. housing
19	(1) scattered
20	(2) clustered
	b. institutional - commercial
21	(1) single building
22	(2) clustered
	c. industrial
23	(1) single building
24	(2) clustered
	2. Shoreline Stabilization
25	a. bulkhead and jetty
26	b. seawall
27	c. groin
28	3. Docks and Piers



Geological quadrangle maps and status of photorivision.



Surficial geology map coverage.



Intervals covered by Beach Erosion Control studies.

Figure 6 . Coverage of government publications.

SURFICIAL GEOLOGY

The straight line distance across the study area, from Merwin Point to Watch Hill Point, is about 60 statute miles. The irregularity of the coast creates a greater extent of shoreline, whose exact length depends on how "shoreline" is defined. In this study, shoreline is loosely defined as the land-sea boundary including that bordering on islands and large salt marsh creeks and extending up major rivers a few miles. Determined accordingly, the shoreline length is about 375 miles.

The surficial geology has been mapped for 9 of the 11 $7\frac{1}{2}'$ quadrangles pertinent to the study area. These maps are a valuable source of information and could not be improved upon by less than an extensive study. Therefore, these maps are submitted as part of this report - for review purposes reduced copies are included as Figures 7 - 17. For the Essex and Old Lyme Quadrangles, in preparation by R.F. Flint, all references are directed to the 1970 photorevised topographic maps (Figures 12 and 13). Flint's preliminary work has been consulted and surficial information for those quadrangles given here is based on his work.

Table II summarizes the composition of the immediate shoreline. In this table the surficial unit in actual contact with tidal water is considered shoreline. The results differ appreciably from those relating the areas of ~~x~~ surficial types in the coast, which is what a visual impression gives. A till outcrop fronted by a beach deposit

TABLE II Surficial composition of the immediate shoreline in quadrangles from Merwin Point (Woodmont) to Watch Hill Point (Watch Hill).[a]

	Beach Sand	Peat	Outwash/ Alluvium	Till	Bedrock	Artificial Fill	Total
New Haven Woodmont	8.7	19.5	1.3	1.1	1.1	15.9	47.5
Branford	3.5	13.5	0.83	2.8	13.7	3.2	37.5
Guilford	2.7	19.3	1.9	1.7	7.1	4.2	36.9
Clinton	7.7	21.6	2.5	1.2	0.42	3.5	35.6
Essex[b]	6.1	18.5	-[d]	-[d]	-[d]	2.6	28.7
Old Lyme[b]	5.3	27.5	-[d]	2.8	-[d]	5.1	40.9
Niantic	6.0	9.0	10.8	4.7	5.0	2.3	37.8
New London	8.1	8.6	7.3	9.8	3.5	4.5	42.0
Mystic	12.6	23.0	10.7	6.1	4.6	4.0	61.1
Watch Hill[c]	1.6	2.9	-[d]	2.4	-[d]	0.5	7.4
							375.4

[a] Distance in miles

[b] Based in part on preliminary maps by R.F. Flint (Peoples, personal communication).

[c] Only part of the quadrangle in the study area.

[d] - = minor amounts

is classified as beach; a thin strip of marsh surrounding bedrock is considered peat shoreline. This measure is a useful one because, for example, the occurrence of marsh along a coastal segment, whether wide or narrow, relates the same message regarding the energy level of the area.

The beach shore cannot be used as a measure of recreational potential. As discussed later, the high value indicated for Mystic Quadrangle occurs in large part on Sandy Point (an island) and Napatree Point while the remainder consists of small, inaccessible beaches. The abundance of peat shoreline is mainly a measure of the occurrence of large marshes in the coast. The absence of peat shoreline, and marsh, in Niantic and New London Quadrangles is striking and difficult to understand. The roughly inverse relationship between peat and outwash shoreline in Table II results in part from the major occurrence of both in backwaters where peat, if it occurs, will often cover any outwash.

The abundance of bedrock is a measure of dearth of sediments and lack of shelter. Thus, the Mystic Quadrangle, which is characterized by outcrops is sufficiently sheltered that marsh or beach form the immediate shoreline. Niantic also has a fair abundance of bedrock outcrop but this is largely covered by till and other sediments. Branford bedrock lacks both sediment cover and offshore shelter.

The shoreline consisting of artificial fill does not include artificial beaches which would add significantly to some quadrangles (New Haven, for example). The value for Old Lyme, includes sand dredge spoil dumped on marsh in the mouth of the Connecticut River (preliminary map of Flint; Peoples, personal communication), but otherwise, artificial fill is either behind a seawall or is revetted.

The total shoreline mileage is a measure of irregularity on all scales through that of large marsh creeks and estuarine rivers. Thus, Branford, which is probably most irregular on a large scale, ranks only about sixth; small marsh deposits also reduce the shoreline somewhat.

RECENT MAP REVISIONS

Photorevisions of older quadrangle maps (mainly 1958 issues) have been prepared for some quadrangles by the USGS using 1970 aerial photos. Changes in shoreline are among those indicated although the primary objective was to update road construction and urbanization. Many changes clearly result from map error, in most cases probably on the previous map. For example, Quarry Road on Great Neck (Niantic Quadrangle) is shown displaced south about 200 ft. along with the row of houses which line it. Also, a square artificial pond near Trumbull Airport (New London Quadrangle) is shown rotated and moved south about 100 ft. Other examples could be cited.

In locating the mean high water line, maps based on photos are susceptible to errors resulting from tidal stage and season of the year. Since most aerial photos are taken during early spring, exposed beaches would be expected to show minimum berm widths and recession would be emphasized. Further limitation in ascertaining change is inherent to the scale of the maps. The lines delineating contours or surficial units on the 1:24,000 scale maps are about 7 ft. wide at real scale. On maps meeting National Map Accuracy Standards, 90% of well defined points are shown within 40 ft. of their correct position (39); the position of mean high water, however, is considered "approximate". Shrinkage and change in paper dimension, probably as great as 1%, could amount to an error of more than 300 ft. measured over a large distance. Therefore, errors of the same magnitude as all but the largest shoreline changes indicated are quite possible. Whether a change is real, therefore, depends on a judgement based on other factors. Individual cases will be discussed in the section to follow and general criteria cannot be given. However, changes which would require great loss of bedrock are viewed with skepticism.

Table 3 summarizes indicated changes (both gain and loss) for photorevised quadrangles according to surficial shoreline composition. Accretion on the old shoreline resulting from new artificial filling is included with changes in the old surficial composition. This most commonly affected outwash, till, bedrock and old artificial fill shores, while changes in beach and peat are mostly natural; the relatively great changes in beaches and peat can be explained in terms of the fact that other kinds of shoreline are essentially entirely protected by seawalls. Changes in bedrock are partially a result of artificial~~ly~~ filling but, in general, are considered map errors. This directly accounts for only 4% of all changes, but if incorrectly-mapped adjacent shoreline is included, the percentage of error would be much higher.

The judgement involved in the photorevision process implies an element of variability among individual cartographers. The pronounced increase in changes toward the east (Table 3) might result partly from this variability since all quadrangles were not revised by one person and because the same trend is suggested in bedrock changes.

TABLE III Coast lengths[a] shown changed (deposition, erosion and map error) on 1970 photorevised quadrangle maps according to composition of the shoreline.

	Beach Sand	Peat	Outwash/ Alluvium	Till	Bedrock	Artificial Fill	Total	% Shoreline
Clinton (9 yrs)	0.23	0.19	-	-	-	0.26	0.7	1.9
Essex	1.1	-	-	-	-	-	1.1	3.8
Old Lyme	1.1	2.3	-	0.19	-	0.49	4.1	10.0
Niantic	2.8	4.8	0.22	1.3	0.26	0.6	9.9	26.4
New London	5.7	2.7	1.1	3.8	1.4	3.5	18.2	43.3
Mystic	5.4	1.4	2.0	0.1	0.2	2.2	11.3	18.5
	16.33	11.4	3.3	5.4	2.0	7.1	45.5	

[a]In miles

DISCUSSION OF SHORELINE

Bloom's subdivision of the coastline (5) represents a natural geomorphological classification and is useful for discussion and management purposes. However, for the purposes of this discussion, reference to surficial geology and topographic maps makes the quadrangle subdivision more convenient, even though it is not in itself informative. For review purposes, copies of the maps are included but these are inadequate substitutes for the published versions.

NEW HAVEN AND WOODMONT QUADRANGLES

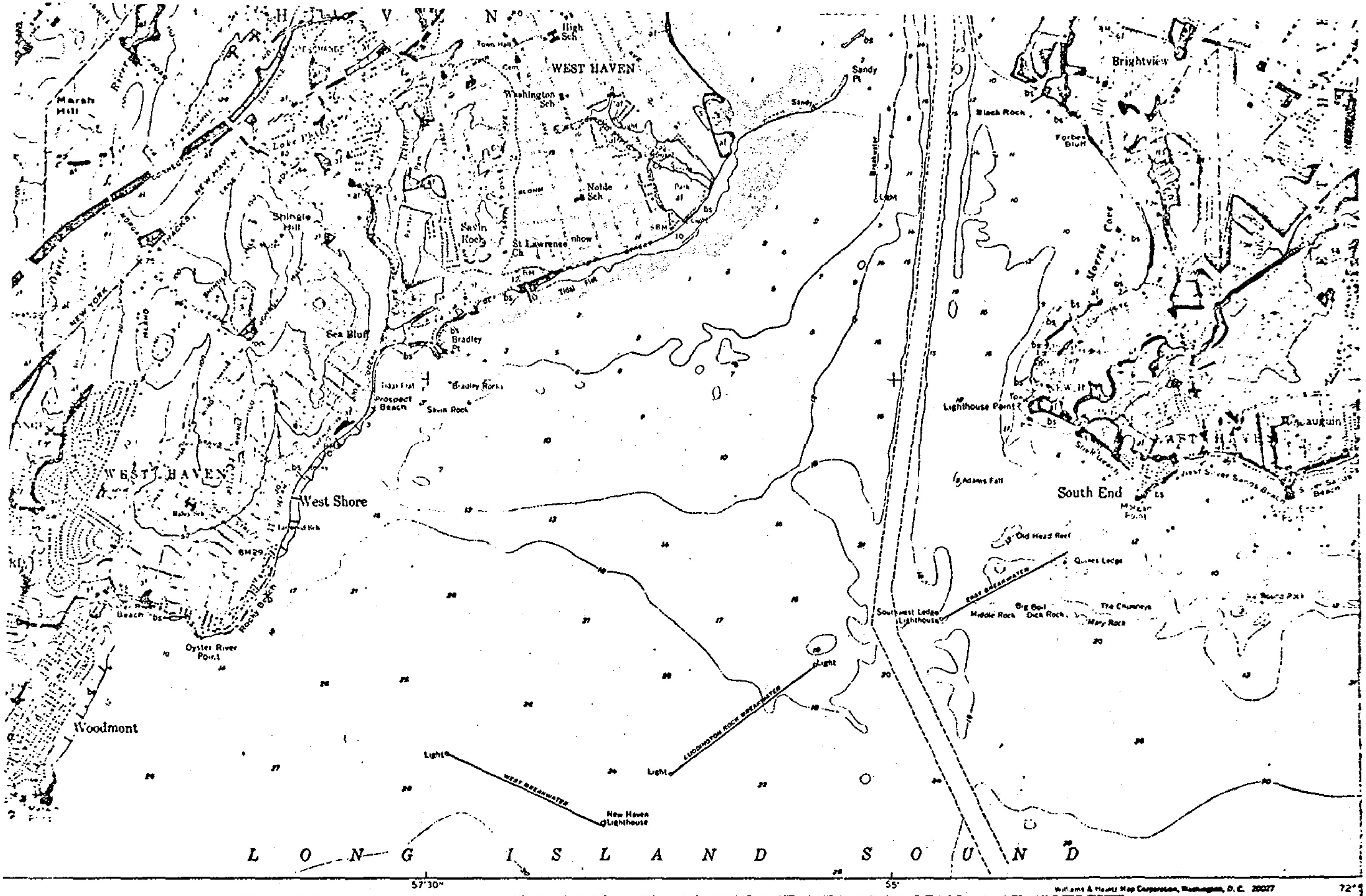
General

The New Haven and Woodmont Quadrangles contain about 9 miles of beachfront which is highly accessible and mainly artificial. About a third of the shoreline consists of artificial fill, not including the man-made beaches. Bedrock constitutes only 1.1 miles of shore but in places this occurs as conspicuous cliffs, such as Forbes Bluffs. Outwash and till are not common at the immediate shore. Roughly 19 miles of peat shoreline occurs in marsh creeks in the vicinity of the Quinnipiac River. The large scale form of the coast centers on the deep bedrock valley which underlies New Haven Harbor (29).

Discussion

For several miles northward from Merwin Point, a prominent bedrock outcrop, the shore consists mainly of artificially nourished beaches backed by continuous seawall and crossed by many groins. Though responding to diminished wave energy resulting from breakwater construction across the harbor entrance, the northward littoral drift has probably increased over historical rates owing to the artificially increased supply of sand. One manifestation of this drift is the lengthening of Sandy Point spit which on a 1890 USGS map is shown extending only to the west end of the adjacent breakwater.

Woodmont Beach received 171,000 cu. yds. and 63,000 cu. yds.

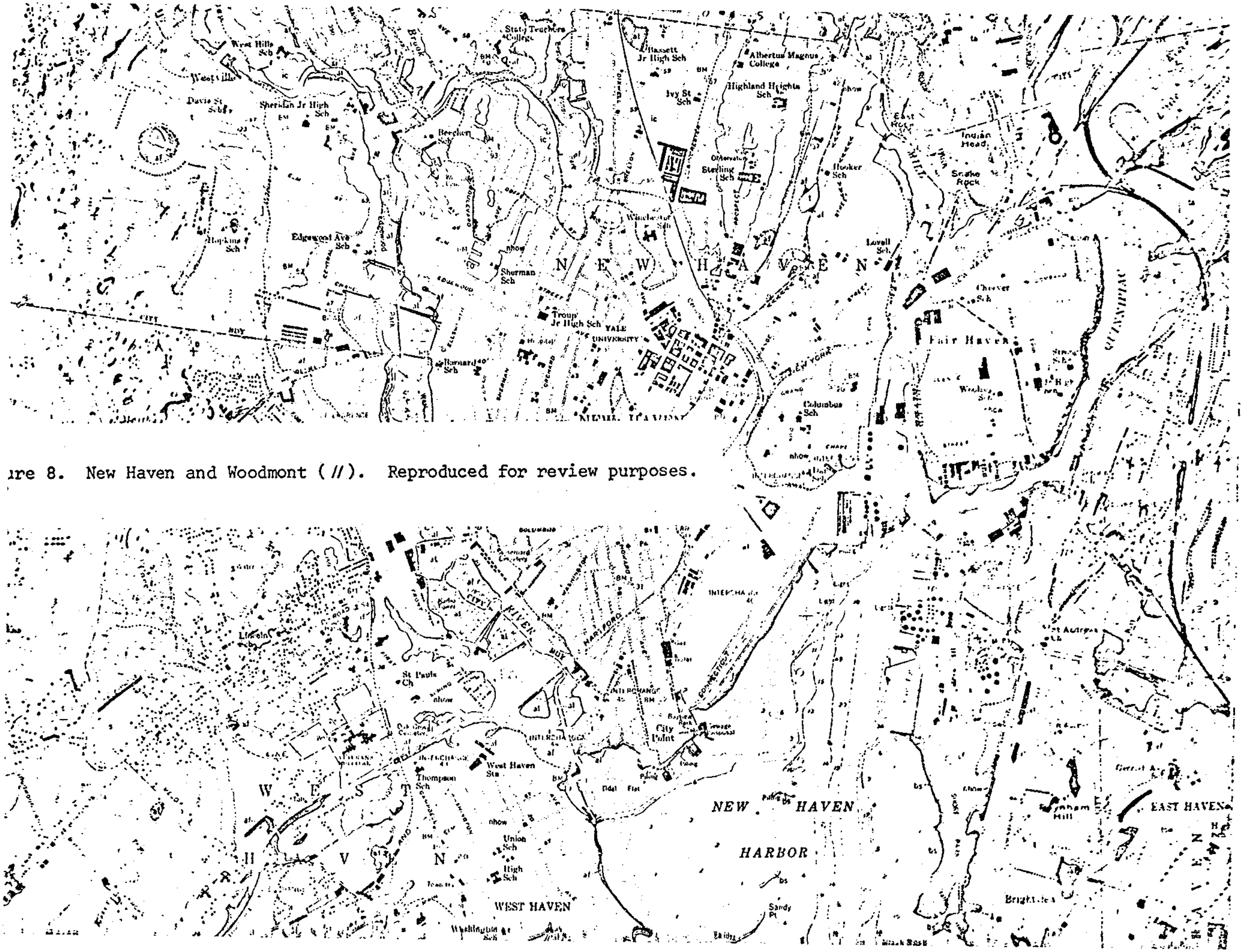


GEOLOGIC MAP OF THE NEW HAVEN AND WOODMONT QUADRANGLES, CONNECTICUT

Surficial Geology by Richard Foster Flint, 1960-1963

by U.S. Geological Survey
y USGS, USC&GS, and Connecticut Geodetic Survey
hy from aerial photographs by photogrammetric methods,
otographs taken 1949. Field checked 1951 and 1954. Woodmont revised 1960
projection. 1927 North American datum
ct grid based on Connecticut coordinate system
ght 1965
Connecticut

Figure 7. New Haven and Woodmont (11). Reproduced for review purposes.



ure 8. New Haven and Woodmont (//). Reproduced for review purposes.

of sand in 1959 and 1964, respectively, which in subsequent surveys has been observed spilling over the northward groins (19). The shore in the vicinity of Oyster River Point consists of till, long stabilized by bedrock outcrops and boulders. Sand from the south must move quickly past this section or be deposited offshore. From the north end of Rocky Beach to Cove Creek, referred to as Prospect Beach by the BEB, broad sandy beach is the result of extensive sand placement. The area received sand barriers and 302,000 cu. yds. of sand in 1957 (19) of which about 5%/yr. drifted northward initially (46) and some northward drift undoubtedly continues. East of Bradly Point artificial sand placement has been greatest of any location in Connecticut but is poorly documented. The BEB reports only that more than a million cu. yds. of dredge spoil was placed at Savin Rock along a 1.5 mile stretch of beach in 1948-49 (36). At low water the sand presently extends well beyond the seaward end of several groins, which along with other features testifies to the abundance of supply.

Sandy Point and the larger submerged structure on which it lies probably receive much of the material lost from beaches to the south. It is remarkable that Sandy Point has continued to grow away from but in the lee of the adjacent breakwater.

North of Sandy Point with rare exception the shore consists of artificial fill behind seawalls, characteristic of the metropolitan development around New Haven Harbor. However, the marshes of the Quinnipiac River, containing peat and mud deposits up to 15 ft. thick (4), front on many miles of creek. On the east side of the Harbor, the beaches bordering East Shore Park consist entirely of reworked artificial fill and are very recent in origin (11). In Morris Cove, just south of Forbes Bluff, there occurs an uncommon section of outwash shore which, prior to the development of New Haven, may have been widespread.

Lighthouse Point Park beach received an unknown amount of channel dredge spoil in 1949 (19) and a groin in 1958 (38). Shell Beach, to the east is a spit which probably overlies a thin peat deposit (18). In 1929 it was described as a wide bar with a dune backshore (26) suggesting a relative abundance of sand. The shore configuration suggests a westward tendency to littoral drift. Silver Sands Beach and West Silver Sands Beach tie South End Point to the mainland and probably also overly marsh peat. West Silver Sands Beach received 160,000 cu. yds. of sand fill in 1957. As in the adjacent area, littoral drift is apparently not great.

BRANFORD QUADRANGLE

General

The coast of Branford Quadrangle is characterized by a large number of bedrock exposures (a total of about 14 miles of shoreline) and islands which project from water and marsh alike. The coastline might be represented as a nearly straight line on a small scale map; however, it possesses a complexity of intermediate and fine structure through that due to joint control measured in meters or tens of

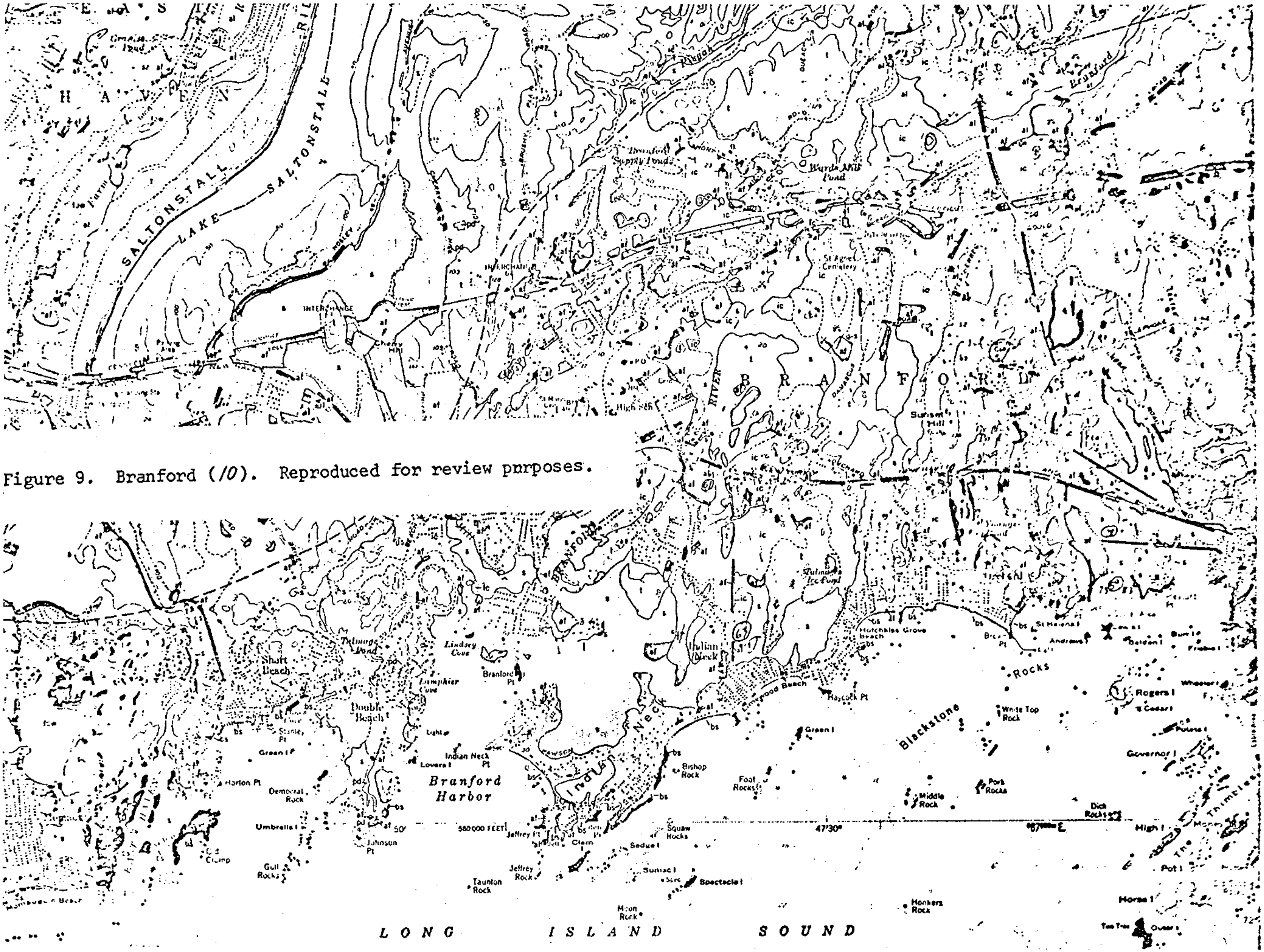


Figure 9. Branford (/0). Reproduced for review pnrposes.

meters. Areas below 20 ft. form a mottled pattern across the quadrangle. The marsh deposits distributed along the coastline in general overlie more than 15 ft. of post glacial sediment; their creeks account for more than 13 miles of shoreline. Offshore islands provide protection to the coast and at least one configuration (Kelsey Island) includes marsh and peat deposits. Very little outwash or artificial fill borders on salt water but till makes up more than 3 miles of the shoreline.

Discussion

The tombolo at Lover's Island in Bradford Harbor still serves as a recreation area as described by Sharp in 1929 (26) and major changes there are not evident. As on other rock shore in the area (and in road cuts) joint control is well expressed here. Farther up the Harbor, the small beach at Branford Point received 11,000 cu. yds. of sand in 1963 (19) using natural bedrock projections for containment. Although natural changes in the configuration of Bradford Harbor and estuary are not occurring rapidly, the thickness of marsh and estuarine sediments indicate a post glacial history of deposition. Cores through the marsh just south of the railroad bridge (4) contained 15 ft. of peat and estuarine mud.

The Sound shore of Indian Neck is alternately defended by bedrock and artificial structures. Though shown as till on the map, Flint (12) suggests that Indian Neck and Pine Orchard may actually be end moraine deposits, correlative with those in the Guilford Quadrangle to the east.

Cores from the marsh between Juniper and Pleasant Points (4) contained more than 30 ft. of gray, probably estuarine, muddy sediment under a relatively thin layer of peat (2-4 ft.). This would suggest, again, that the shallows immediately offshore result from post glacial deposition; also, the marsh itself must have formed relatively recently compared with those at Clinton which Bloom (2) attributes with a 3,000 year history.

Marshes in this area and elsewhere are crisscrossed by roadbeds of present and former railroads, electric trolleys and unknown vehicles. These roadbeds inevitably restrict the circulation of water and lead to more brackish, or even fresh, conditions landward. The response on the part of marsh plants is better documented (e.g. 47) than that of the animal communities which depend on them, but overall, such changes are considered undesirable. However, these roadbeds have undoubtedly also provided protection from flooding and in that sense have had unintended benefits.

An increasing proportion of the coast in the eastern part of the quadrangle consists of artificial fill associated with residential development of low, rocky or till-covered promontories. Filling activities are primarily limited to the more protected areas, however.

GUILFORD QUADRANGLE

General

In the west the Guilford Quadrangle resembles the Branford Quadrangle with abundant bedrock exposures at the shoreline. Beach, outwash and till are relatively minor, even in comparison with artificial fill which fronts on about 4 miles of shoreline. The banks of large marsh creeks of the East and West Rivers account for most of the 19 miles of peat shoreline in the quadrangle. In the east, end moraine deposits and outwash in the backshore account for the occurrence of beaches there and the lack of bedrock exposures.

Discussion

The marsh east of Stony Creek has received intensive study by Bloom (6) over the last decade. A relatively thin peat deposit, a few feet thick, overlies more than 40 ft. of gray mud (4) implying a depositional origin for the adjacent nearshore shallows. Bloom describes the edge of the marsh as a 2-3 ft. cliff with overhanging edges and adjacent detached peat blocks; but after 2 years no erosion or change could be detected even on the detached blocks. From this and similar examples elsewhere he concludes that though the "cliffs" give the appearance of rapid erosion, whatever retreat occurs must must do so at irregular intervals. At the same location, studies of upward accretion of the marsh surface yielded an average value of 10 mm/yr.

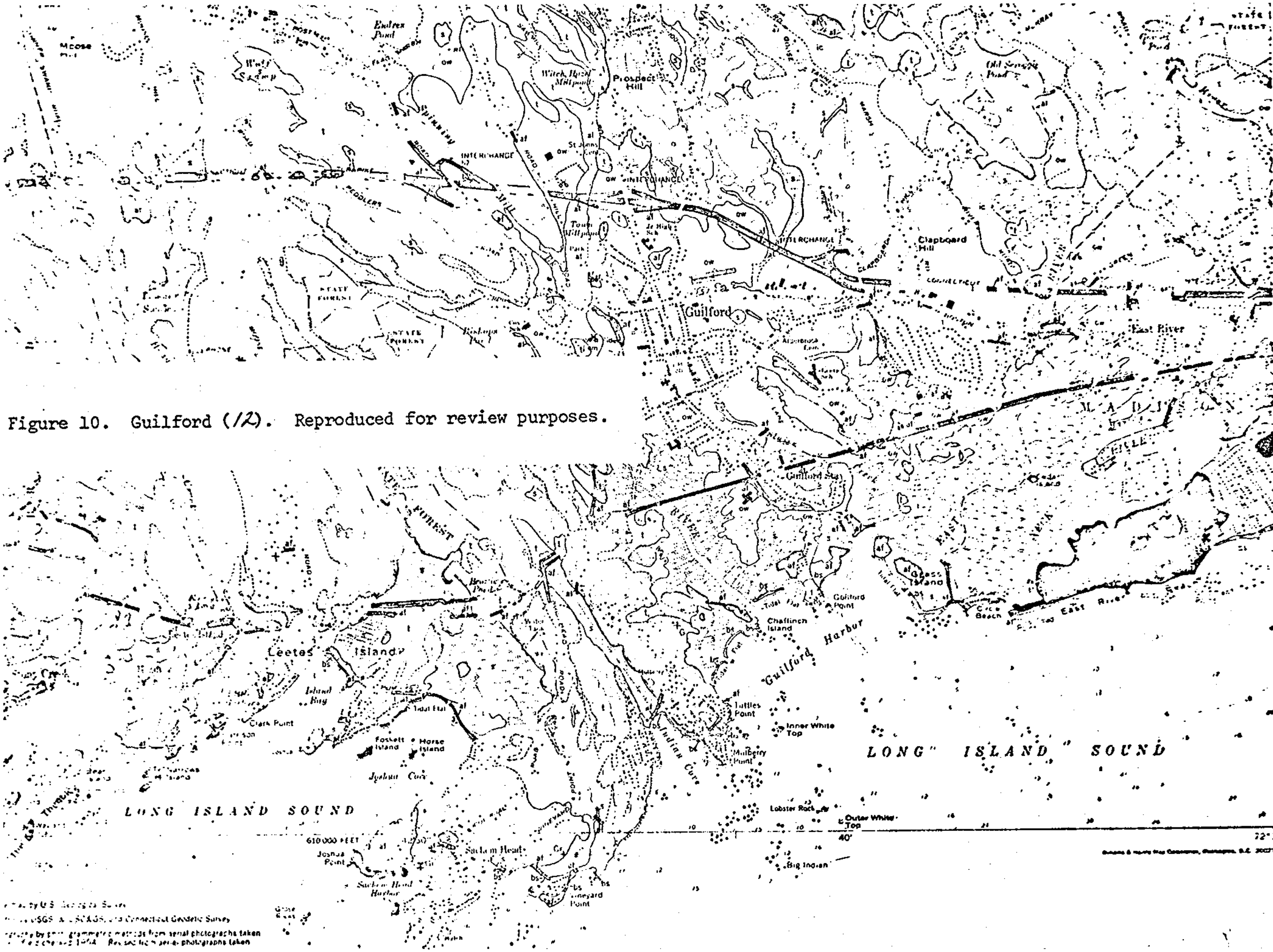


Figure 10. Guilford (1/2). Reproduced for review purposes.

The marsh behind Island Bay is protected from erosion by artificial fill which now supports a road and houses but which may originally have been part of the electric trolley route that crossed Joshua Cove (26). The eastward end of the fill is fronted by an elongate heap of large boulders, presumably placed by the residents. The small beach to the west consists substantially of small bivalve shells and at the time of the field check had accumulated a thin mantle of flotsam and detritus.

Cores from the marsh behind Joshua Cove (4) contained more than 32 ft. of peat and estuarine sediment. A shell beach not shown on the map fills the NW corner of the cove. In 1929 Sharp reported rapid erosion of a marsh deposit occurring seaward of the road bed (now abandoned) and this has apparently completely eliminated that deposit, even though a broad tidal flat offshore might have been expected to minimize wave attack in this location.

The section of the Guilford Harbor Shore consisting of peat has been identified as perhaps the most rapidly eroding in Connecticut (6). That section where peat outcrops seaward of a sand beach deposit between the West River and Guilford Point (called Chittenden Beach) is reported to have receded up to 200 ft. from 1838 to 1933 (34) and up to 180 ft. from 1949 to 1965 (6). Measurable recession has occurred along the marsh edge since Bloom's detailed surveys in 1964-65. He, also, cannot explain the erosion but offers three possibilities as contributing factors: increasing ineffectiveness of offshore islands or boulders to diminish wave energy as a result of rising sea level; increased exposure of the coast as a result of the widespread demise of eel grass beds during the 1930s; and an unaccounted-for decrease of sand supply to the beach with its subsequent loss as a protective structure.

However, while the marsh edge recedes its surface has continued to accrete upwards. Bloom (6) estimates a rate of 4mm/yr. on the basis of burial of datable relics of civilization.

Just east of Guilford Point a small artificial beach (Jacob's Beach) was created in 1959 with 13,000 cu. yds. of sand dredged from the channel to the East River (19) and a groin was constructed at the east end for containment (39). Apparently considerable amounts of dredge spoil was placed on marsh elsewhere in the vicinity.

The Quadrangle shoreline east of Guilford Point becomes free of bedrock outcrops and is characterized by glacial till and beaches. The N-S flank of East River Beach is a spit which has grown northward from a now eroded and submerged till deposit marked only by a field of boulders. The spit is reported to have increased in length by 200-300 ft. since 1838 (34) although tidal flow of the River and management has probably stopped this process. Cores from Grass Island (4) reveal 4-7 ft. of peat overlying 15 ft. of gray mud which thins to the south. A seaward outcrop of peat at the nearby point implies active or impending erosion at that location.

Eastern reaches of East River Beach front an end moraine deposit. At Hogshead Point seawalls backed by artificial fill have been constructed to protect this exposed section of the coast.

Beach here is absent; littoral drift is westward.

CLINTON QUADRANGLE

General

The shoreline of the Clinton Quadrangle is relatively regular compared with that to the west but areas below 20 ft. nevertheless extend inland across a 2 mile wide band of coast. The section west of and including Hammonasset Beach (the State's best recreational beach) is designated a Critical Erosion Area (38) in part, apparently, because existing facilities are inadequate to serve the public demand. Marsh creeks in this quadrangle give rise to about 22 miles of shorefront which, along with beach makes up more than 80% of the total.

Discussion

Along the Madison coast, beach alternates with seawall to form the shoreline. The shallow marsh west of the golf course is different from other marshes identified to the west in that it contains only about 6 ft. of peat over the glacial drift, and shows evidence of a predominantly fresh or brackish history.

Tuxis Island and Gull Rock were cited by Sharp (26) as areas of erosion prior to 1929. Reference (based on hearsay) was made to a former vegetated tombolo extending to Gull Rock. The existence of such a feature in historical times seems doubtful however; BEB maps dating back to 1838 (34) do not even show Gull Rock--an unlikely

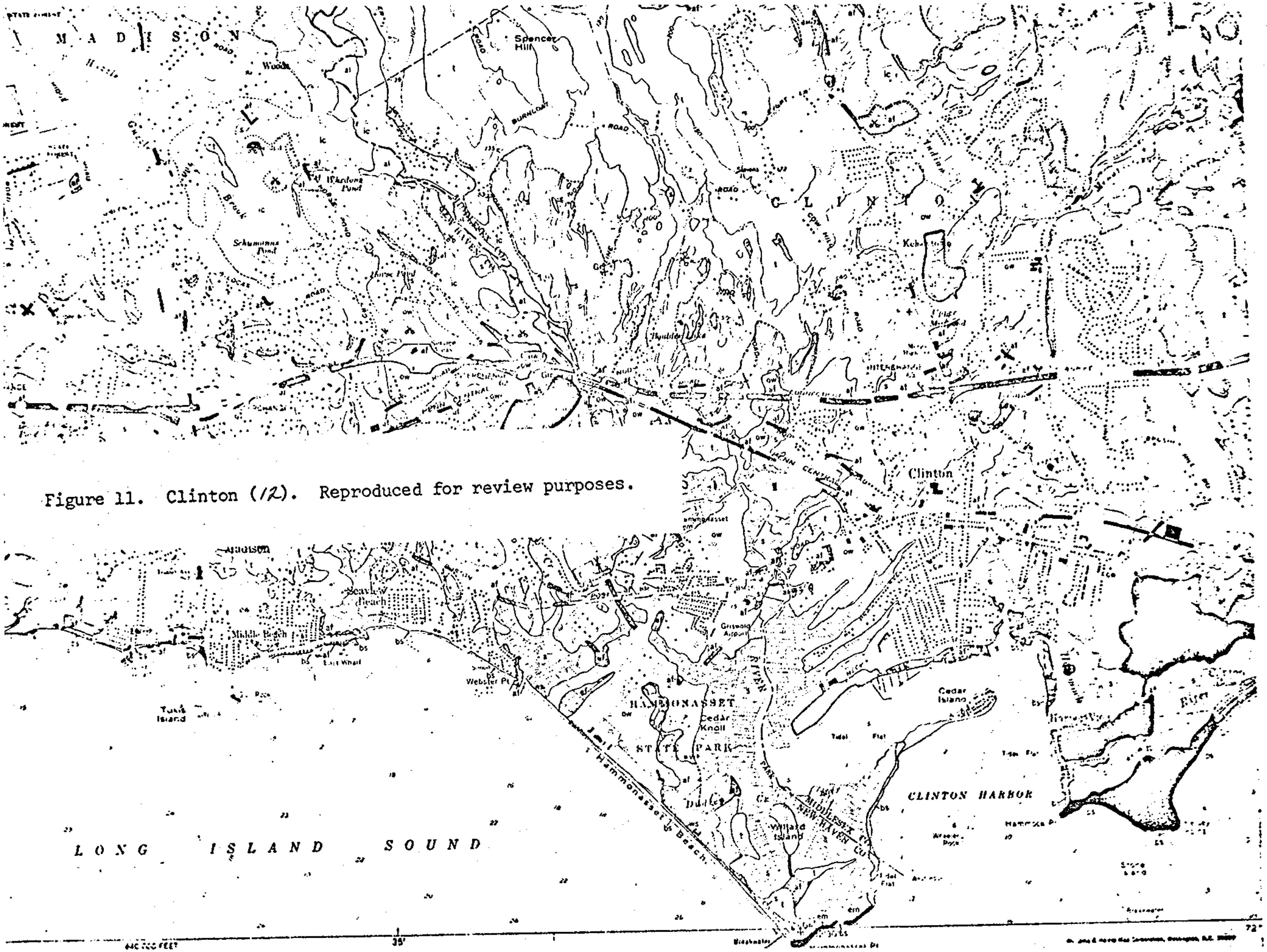


Figure 11. Clinton (1/2). Reproduced for review purposes.

omission if a prominent beach feature existed there. The 1890 USGS map shows the island but no tombolo. At present a tombolo-like structure is visible at low tide and a timber groin ties Gull Rock to the mainland, but accretion is not appreciable. Recent defenses against erosion in this section have been directed at maintenance of existing seawalls.

At Seaview Beach, Fence Creek executes some remarkable "meanders" in a marsh containing an unusually thick peat deposit; up to 20 ft. (4). The "barrier" extending eastward across the front of the marsh does not have a marine origin but consists of outwash. The beach on the opposite side is a barrier spit, however, with a small marsh-filled lagoon behind it and over which it is probably retreating. Residents have constructed several catwalks across the marsh to the beach.

The marsh behind Webster Point also contains relatively thick peat (4). It overlies estuarine sediments that contain abundant shells in places. The relatively fixed position of Tom Creek outlet over a century (34) suggests a predominent westward littoral drift. Breakwaters and fill were added there for navigational purposes. The dunes behind the spit indicate an abundance of supply which may in part be attributed to the placement of sand along Hammonasset Beach in 1955 which amounted to 378,000 cu. yds. (19).

According to the BEB (34) the west end of Hammonasset Beach was eroded about 100-150 ft. over about a century while the east end accreted an equal amount. The distribution of dunes is consistent with this general interpretation. At present, low dunes at the eastern end are moving onto the road which is probably improperly located. Hammonasset Point is a highly eroded end moraine deposit, studded with massive boulders that measure more than 6 ft. in diameter. The line of boulders extending to the NE shows the trend of the moraine and is an indication of the shoreline of the geologic past. In the marsh behind the end moraine deposit and that near Cedar Knoll a relatively thin peat overlies 20-30 ft. of soft mud (4).

Littoral drift is northward along the east side of Hammonasset Point and has formed a tombolo which connects Cedar Island to the shore. Flint (12) states that Cedar Island and Willard Island are probably segments of end moraine. The tombolo to Cedar Island is shown alternately breached and intact in maps dated from 1833 to 1949 (34). It was breached again in 1954 and some steps have been taken to stabilize that section.

The east shore of Clinton Harbor is predominantly artificial fill on top of beach and dune deposits (33). A sediment profile which crosses the beach (2) suggests that underlying sediment is glacial drift. Bloom's studies of the Clinton marsh show it to be deep, containing about 9 ft. of peat and up to 30 ft. of mud (2). The marsh is accreting vertically at from 4 to 16 mm/yr. (6).

The shore from Hammock Point to Kelsey Point was subject to considerable wave attack and erosion (33) before protected by seawalls, groins and riprap revetment. Changes attributed to the construction of the offshore breakwater include the formation of the beach west of Kelsey Point (33) and erosion of offshore sediment which had previously allowed ox teams to be driven to Stone Island at low tide (26).

Clinton Beach is crossed by abundant "home made" groins intended to retard erosion. Presumably they or their predecessors have been successful since stability had been achieved by about 1933 while up to 200 ft. of erosion occurred in the preceding century (33). The stabilization effort was augmented in 1964 with 19,000 cu. yds. of placed sand. Beach rotation indicates littoral drift tends to be eastward(19).

ESSEX QUADRANGLE

General

The USGS surficial geology map of this quadrangle is not yet completed. However, preliminary work conducted by R.F. Flint has been consulted (Peoples, personal communication). Final publication will probably not be completed for a year or more, but the finished map should be available for limited inspection at the Connecticut Geological and Natural History Survey within a few months (Peoples, personal communication).

Marsh deposits are shown on topographic maps and large ones are plotted by Hill and Shearin (18). Information on marsh cores from within the quadrangles is given by Bloom (4). Generally, end moraine deposits correlative with those of the Clinton (12) and Niantic (14) quadrangles constitute the major high areas of the coast (see figure 2). These include areas in Grove Beach, Patchogue, Old Kelsey Point, Saybrook Manor, Old Saybrook, Cornfield Point and the three ridges extending northward and eastward from there. Most of the shoreline is fronted by narrow beach. Outwash, till and bedrock exposures on the shoreline are rare; artificial fill borders almost 3 miles of the shoreline.

Large marsh creeks associated with the Menunketesuck and Patchogue Rivers in the east and the Oyster, Plum Bank and Back Rivers in the west give rise to about 19 miles of peat-fronted shoreline.

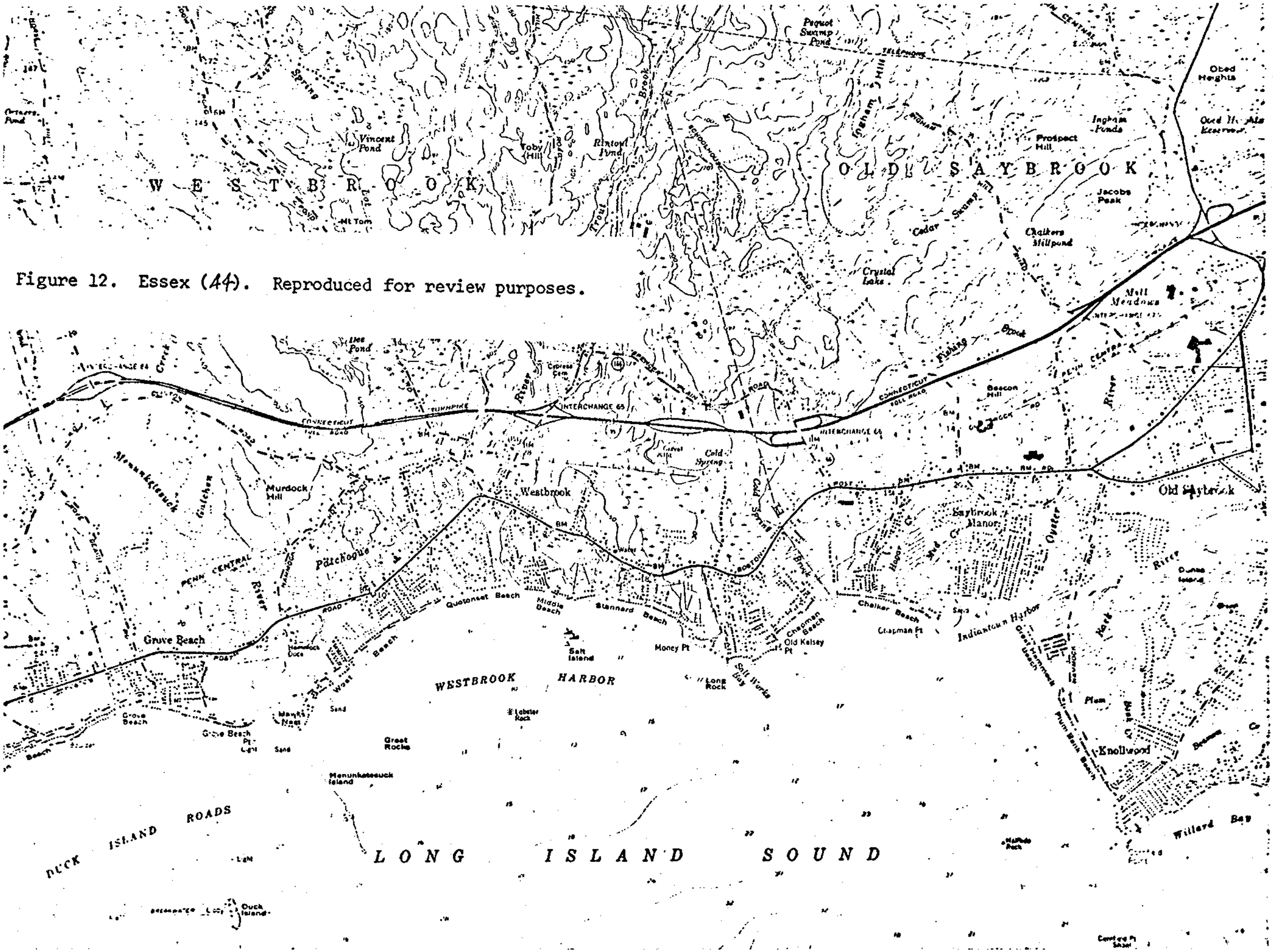


Figure 12. Essex (44). Reproduced for review purposes.

Discussion

"Clinton Beach" continues a short distance from the Clinton Quadrangle but from the point of view of beach compartments extends east under different names to Menunketesuck Island. Grove Beach is classified as a sand spit by the BEB (33) who indicate 300 ft. of recession in the century prior to 1933, when stability was apparently achieved. The area is regarded as a Critical Erosion Area (38), however, perhaps in the sense that beach use demands are locally high. The deep marshes behind the spit include 5-8 ft. of peat overlying 10 ft. of mud (4).

In Westbrook Harbor littoral drift is westward, along narrow beach. Independent sources (33,44) indicate shoreline stability in recent years although erosion has been reported along the eastern end of West Beach during the past century; up to 350 ft. of deposition is reported at the west end during the same period (33). 1000 cu. yds. of sand placed in this area in 1950 to augment natural accretion was mostly lost within a few months of the same year (33).

The opposing directions of littoral drift in Duck Island Roads and Westbrook Harbor converge at Menunketesuck Island, an eroded till island, which the 1890 USGS map shows tied to Hawk's Nest, another till deposit. Sharp (26) states that the "tombolo" was visible only at low tide in 1929 but the 1958 topographic map shows a nearly complete tombolo with a small breach a few hundred feet from shore. Changes during the last 12 years (44) result from construction and filling at Hawk's Nest but also include an opening of the breachway. Other recent changes involve a lengthening of Menunketesuck Island southward and accretion on the east side. From the foregoing and on the basis of bathymetry it seems possible that sand converging on Menunketesuck Island is moved offshore to deep water along both sides of the Island.

The shore east from Chapman Point, a bedrock outcrop, to Cornfield Point is regarded as a Critical Erosion Area (38). Chapman Beach, which backs on glacial till, has a history of both erosion and accretion (33) although here as elsewhere to the east, no changes have occurred recently (33,44). Littoral drift, judging from the distribution of sand around groins, presently tends eastward and with the northward drift along Plum Bank Beach reports of serious erosion around Indiantown Harbor (33,26) raise important questions regarding the sand budget.

Chalker Beach received 97,000 cu. yds. of sand fill in 1959 (19) and the area still gives the impression of abundant supply. The marshes to the immediate east and west overlie about 12 ft. (4) of postglacial sediments that suggest an evolution from fresh bog to estuarine embayment to tidal marsh. Beach sections between Chapman Point and Cornfield Point rest on marsh which may contain relatively thick deposits of peat and mud similar to those cored by Bloom to the east (4). Instances of pronounced shoreline recession (33) following construction or artificial filling in such areas (26) might be explained in terms of compaction of the underlying peat (cf. 3) or flow of muddy sediments. The Great Hammock Beach area, described by the BEB as "not suitable for development" (33) is apparently subject to periodic flooding. The small road extending northward among cottages is little elevated over the marsh surface in places. During spring tides it is regularly submerged along with the rest of the marsh.

Cornfield Point is a prominent headland subject to occasional intense wave attach. Reefs extending to the SW may represent the drowned extension of end moraine deposits found here (Flint, preliminary surficial map). The shore has been well protected by 10-15 ft. seawalls and groins for four decades, in addition to that protection offered by massive boulders which lie offshore. Nevertheless, coastal defenses did not prevent drastic erosion and loss of houses during recent hurricanes, particularly along the west flank of the Point.

THE OLD LYME QUADRANGLE

General

The USGS surficial geology map of the Old Lyme Quadrangle is presently under preparation by R.F. Flint (Peoples, personal communication). Comments made concerning the Essex Quadrangle in this regard also apply to Old Lyme. In his preliminary work, Flint shows end moraine deposits extending across the quadrangle (Peoples, personald communication) but they form the coast only west of the Connecticut River where they occur as prominent topographic highs:

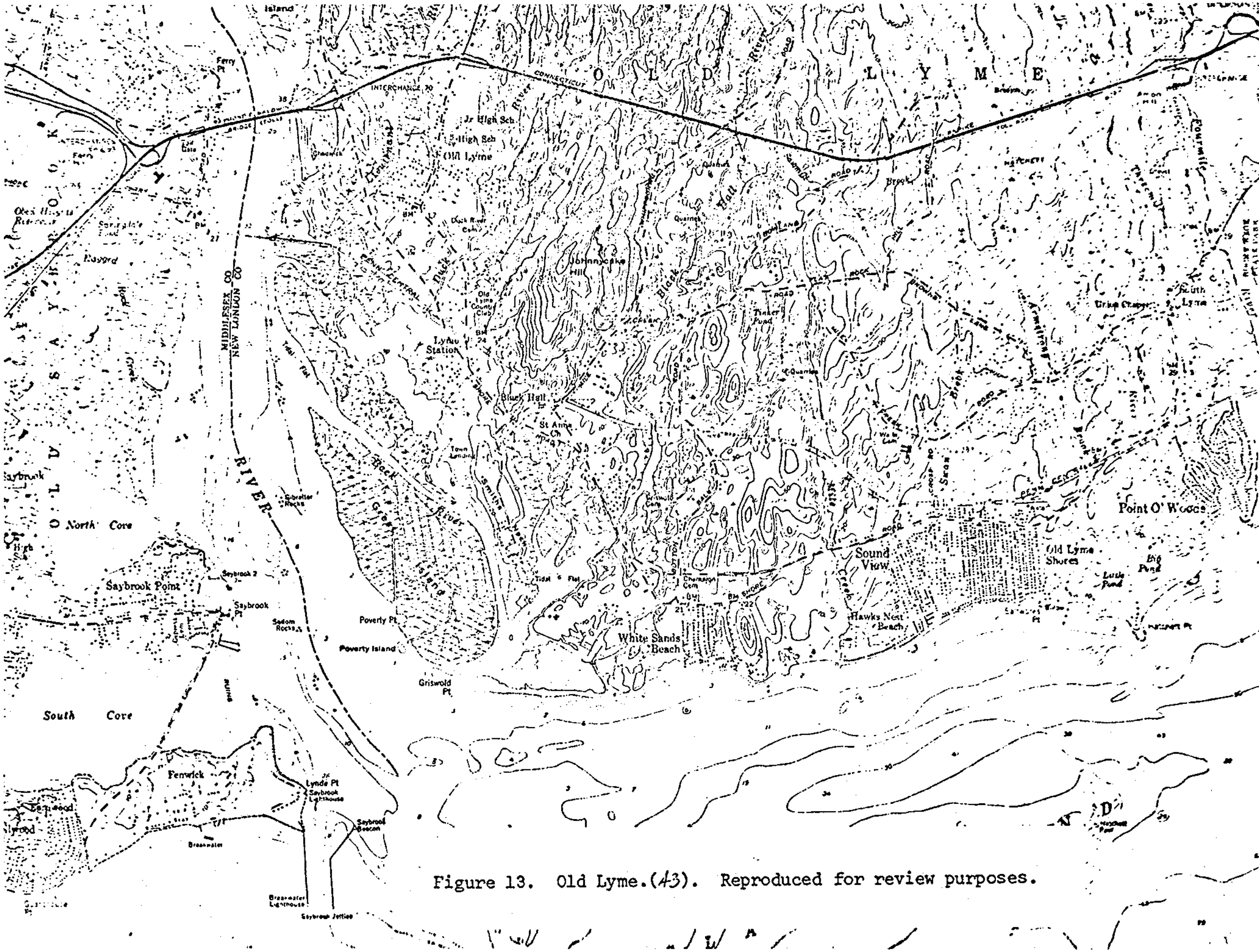


Figure 13. Old Lyme.(43). Reproduced for review purposes.

Knollwood, Fernwood, Fenwick, Saybrook Point and Old Saybrook. East of the River end moraine deposits lie inland.

The roughly 28 miles of peat-fronted shoreline lies entirely in the protected waters of the Connecticut River (the study area extends to the Baldwin Bridge). As in the Essex Quadrangle, outwash and bedrock form negligible portions. Five miles of artificial fill, mainly the product of dredging, lie as a veneer on marsh in the River, although artificial filling in the usual sense has occurred at Saybrook Point. All 5 miles of beach face the Sound with the exception of that at Lynde Point and on the north side of Griswold Point.

Discussion

The shore from Cornfield Point east to Fenwick Point consists of end moraine eroded to its present configuration during the last few thousand years. The present stability of the coast (33, 44) depends not only upon massive seawalls and groins, backed along Guardhouse Point by riprap revetment, but also upon naturally occurring boulders.

Relics of past efforts to curb erosion take the form of abandoned and washed out sections of seawall 50 ft. seaward of the present structure. Beaches along this stretch are scanty and ephemeral; sand supply is either small or passes rapidly by the area.

The marsh just east of Fenwick is of unknown thickness. At the Sound shore it outcrops on the seaward side of the sand barrier which has moved northward over its surface. Similar to related beach structures in Connecticut and Rhode Island, the berm has been subject to overwash and rapid retreat during storms (26) but in the near future overall recession of this shore should not exceed that of the adjacent shoreline, which is stable.

The shoreline south of Lynde Point has been strongly influenced by the construction of the Saybrook Jetties. In 1851 the shoreline followed the road and line of cottages extending SW from Lynde Point (33). The present shoreline has apparently reached equilibrium in the modified energy-sand supply regime, since it has not changed much in recent years (43). The alteration in configuration occurred quite dramatically, however, involving progradation rates of 10-20 ft. per year for a net accretion of up to 800-900 ft.

The west shore of the Connecticut River has shown no detectable changes in recent years (44) with the exception of those due to artificial filling at Saybrook Point. The marsh peat north of North Cove is relatively thin but overlies up to 30 ft. of muddy sediment (4). The presence of boulders between the marsh and the River channel, if they are natural, suggests that the marsh occupies a basin separate from the channel. Peat deposits underlying the muddy sediment (4) are evidence that such a basin could never have been a closed topographic form.

Great Island, on the east side of the River, is one of Bloom's detailed study areas (6). He indicates that vertical accretion averaged 3 mm. per yr. despite a scoured appearance to the marsh surface. The NW edge of the marsh was receding at a rate of about 1 ft./yr. during the early 1960's.

Griswold Point is a compound recurved spit and as such is quickly identified as a structure likely to be undergoing change. The shore west from White Sands Beach, a Critical Erosion Area (38), has shown both erosion and accretion of measurable amounts during the past 12 years (43). The end of the spit has been extended 400-600 ft. with a resulting increase in beach area. The backshore stability west of the center of the spit has allowed growth of vegetation including terrestrial plants. At the extreme end of the spit, recent structure shows that the influence of flow in the Back River had become appreciable and future northward movement of the spit end will probably increase erosion of the nearby marsh.

Material for growth of the spit has come at least partially from erosion of the end moraine near White Sands Beach. The western "point", shown in the 10 ft. contour, has recently been protected by riprap but the eastern one is eroding at an appreciable rate. Slump blocks containing top soil and living turf lie at the foot of a steep 6-8 ft. cliff; the beach in front is narrow and consists of gravel and pebble lag deposit. Nearby, the exposure of two soil profiles separated by cross bedded beach deposits is evidence of backshore deposition by ancient storms.

The berm crossing the small marsh to the east has been very recently overtopped and landward movement of the barrier seems to be progressing relatively rapidly along with the recession of adjacent shoreline (cf.43). The high aesthetic value of Griswold Point in its "wild" condition would seem to justify extreme caution in attempts to stabilize it, and would perhaps favor periodic returning of sand from the Point if control measures are necessary.

The angular form of the shore at White Sands Beach results from westward littoral drift against an overtopping groin. The beach was nourished in 1957 and 1966 with 37,000 and 14,000 cu. yds. of sand, respectively (19), much of which has probably gone into extension of Griswold Point. Sand retained behind recently constructed groins forms a shoreline which has rotated several degrees counterclockwise from the trend of the adjacent shoreline (19) and demonstrates that the natural orientation favors westward littoral drift.

The streamlined hill east of White Sands Beach represents the first of several till deposits to the east which are separated by marsh deposits but connected at the immediate shoreline by barrier spits which overly the peat. None of this shoreline has shown great change in recent years (43) although its history has predominently been one of recession (1,26,32). Dense residential development of sand barriers overlying thick peat deposits, such as at Hawk's Nest Beach which could rest on 23 feet of peat and mud (4) again raises the question of whether local subsidence may account for the reported shoreline transgression.

The coastline here is protected by nearly continuous seawalls and small groins which in places show several generations of improvement and enlargements. Some of the brooks and creeks crossing the beaches are stabilized in culverts. The shore at Point O'Woods had not changed appreciably in almost a century according to the BEB (32), but McCabe (19) relates a problem of overtopping which resulted in loss of sand to the marsh in back. In 1965 the beach received 24,000 cu. yds. of sand and a stone revetment to raise the berm.

THE NIANTIC QUADRANGLE

General

The Niantic Quadrangle coast is characterized by an abundance of bedrock exposures; a large-scale irregularity resulting from elongated till or till-covered hills; and beaches which front on relatively shallow marshes. Bedrock accounts materially for about 5 miles of the shoreline but indirectly is responsible for much of the small scale configuration. Most of the 6 miles of beach occurs as arcate barriers or tombolos stretching between rock headlands or to bedrock islands. The roughly 9 miles of peat shoreline lies in Rocky Neck State Park and the Pataguanset estuary. Where, for unknown reasons, marsh has not developed, the shore of sheltered waters consists largely of outwash. Eleven miles of shoreline in the Niantic River and Jordan Cove fall in this category. Till makes up about 5 miles of the immediate shoreline.

Discussion

The beach between Land's End and Giant's Neck has a history of both accretion and erosion during the past century.(32) but the western end is fixed by the adjacent railroad embankment. Dunes along part of the backshore reflect a relative abundance of sand.

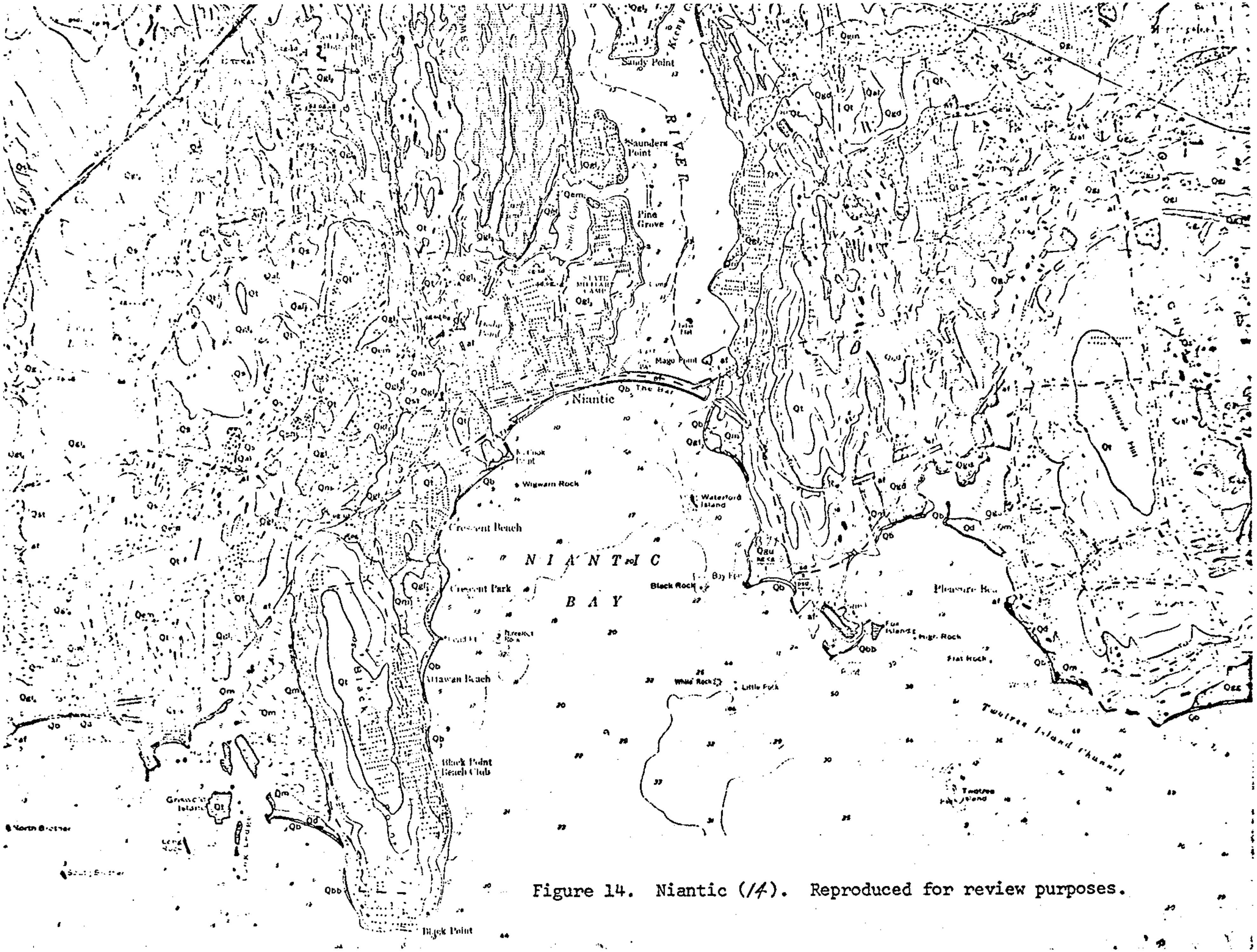


Figure 14. Niantic (/4). Reproduced for review purposes.

At the extreme east end erosion of the beach and dunes for a distance of about 50 ft. behind the remains of an old timber wall would suggest recession of the shore.

The marshes of the Pataguanset River are indicated to have eroded as much as 10 ft./yr. for more than a decade by the photorevised map (42). Quantitatively this seems unreasonable for a sheltered area where artificial alterations are not evident, and may represent mapping error. Further evidence to support this explanation is that the bedrock outcrop on the west shore, north of Watt's Island, is included in the eroded part of the shore--significant erosion of bedrock in 12 years is most unlikely. Some loss of peat is reasonable, however, as the marsh edge in places is subjected to considerable pedestrian traffic.

The marsh behind Watt's Island consists of about 5 ft. of peat directly overlying sand (4). It is shown somewhat enlarged on the photorevised map (42).

Black Point Beach is a tombolo backed by vegetated dunes. It has shown accretion prior to 1883 and no change since (32,42). The beach and the marsh behind it are probably contemporaneous units.

The exposed shore of Black Point consists of till. Despite reports of severe erosion (26) the continuity of features above and below sea level suggests it is a relatively resistant deposit. The BEB reports no significant change since 1883 (32). Along the west shore of Niantic Bay considerable effort has been expended to catch the meager supply of northward drifting sand behind short groins with little success. Boulders and cobbles line most of the shore.

Attawan Beach to the north is reported to have receded 50-100 ft. in the century prior to 1950 (32). The end of the beach near Pond Point has retreated more than 100 ft. in the past 12 years (42) and at present consists of a thin, irregular sand lens resting on a broad cobble pavement. It is possible that the collective effect of the groins to the south has reduced the sand supply which, however, could never have been great.

At Crescent Park slight accretion has occurred behind a breakwater and groin complex and some artificial filling has added to the shoreline.

At the head of Niantic Bay the shoreline is controlled by the railroad bed and highway which cross The Bar, a pre-existing spit. Recent changes within Niantic River result from residential seawall construction (Saunder's Point) and commercial development just north of The Bar and at the gut (42). On the east shore recession is indicated at the tied outwash island south of The Bar and in outwash just north of Bay Point, although the beach to the east of Bay Point has shown accretion (42).

Millstone Point is the site of industrial activities and construction there has modified the adjacent shoreline through artificial filling and placement of riprap.

The marsh-beach island in Jordan Cove owes its triangular shape, in part, to bulkheads which extend along both sides of the back. The spit extending from the west end has enlarged considerably northward and eastward since 1958 while recession of about 100 ft. along the beach front is indicated (42). At Pleasure Beach, filling associated with enlargement of a parking area has modified the shoreline and reduced the size of the lagoon. New groins and seawalls just to the north account for changes there (42). The beach and dune deposits at White Point are apparently relatively stable.

Accretion of sand behind new groins at Seaside Point indicate littoral drift there is eastward.

NEW LONDON QUADRANGLE

General

The 8 miles of beach on the Connecticut shore of the New London Quadrangle occurs as arched barriers or tombolos between rocky headlands or extending to bedrock or till islands. Bedrock accounts directly for 3.5 miles of shoreline. Almost a quarter of the shoreline consists of till (9.8 miles) more than for any other quadrangle in the study area. Artificial fill is common in the Thames River in association with commercial and industrial development (the study area extends north to the Gold Star Memorial Bridge). Peat shoreline occurs in sheltered areas across the quadrangle; outwash deposits, also limited to sheltered areas, occur primarily along the Poquonock River and Palmer Cove.

Discussion

The shore in front of Goshen Cove consists of a dune backed barrier spit which lies in front of, and probably over, a relatively thin marsh deposit. The inlet is not artificially confined and within limits displays the mobility typical of such features. The

Figure 15. New London (/3). Reproduced for review purposes.

inflection in the marsh to the rear may locate the position of former inlet to the west. Recession of the center of the beach shown on the photorevised map (41) may actually represent the winter beach phase of an annual cycle, which would be expected to be accentuated for an exposed beach. A minor riprap groin presently lies nearly submerged in the beach.

With westward progression toward Goshen Point the beach becomes thinner and cobbles and boulders prominent. The dune deposit landward shows evidence of management. However, recent storms have cut a low cliff into its face. Goshen Point is protected by a bedrock outcrop and a field of boulders which extends in front of its east and west flanks. The east side, consisting of till, is also defended by riprap revetment which continues eastward to and along the beach berm where it is mostly buried. This coastal segment, in the vicinity of Harkness Memorial State Park, is aesthetically among the most attractive in the study area. The section west of Goshen Point, designated a Critical Erosion Area (38), should be viewed in light of its unique qualities when control measures are designed.

The tombolo and barrier spit to the east of Goshen Point, also a Critical Erosion Area (38), are shown receded by the photorevised map (41) but this probably largely results from mapping errors because granite outcrops are also shown as having eroded up to 100 ft. in 12 years. The spit at Ocean Beach has clearly extended, however, and now projects westward over the small peat island. Erosion of the marsh is probably associated with the change in the spit.

Ocean Beach was the first area in Connecticut to receive large scale artificial nourishment. Unrecorded amounts were placed in 1940 to repair hurricane damage and 42,000 cu. yds. was placed again in 1965 (19). Redistribution of this sand probably accounts for growth of the spit.

Most of the shoreline changes in the Thames River result from man-made structures. However, the cuspate beach in front of Mitchell Park appears to have moved naturally about 100 ft. northward, without change in form (41).

Map error probably accounts for some of the changes near Eastern Point where bedrock outcrops (e.g., Hobbs Island) are shown moved on the photorevised map (41), although some straightening of the shoreline may have resulted from artificial filling. Shennecossett Beach has a reported history of recession (30,26) up through recent years (41) although filling of the lagoon behind it has been largely artificial and not from beach loss (cf.13). The present level of management there makes permanent recession of the beach seem unlikely even if sand is lost.

Along the east side of Jupiter Point, small natural losses of till occur alongside artificial alterations. Changes in the outwash and peat in the vicinity of Trumbull Airport (41) require both accretion and erosion.

Bushy Point Beach, a tombolo connecting Bluff Point to Bushy Island has a history which suggests instability. The absence of vegetation in 1929 (26) suggests sand movement then and BEB maps indicate recession since 1846 by more than 150 ft. The photorevised map (41) shows 50-100 ft. northward movement of the tombolo and breaching of the western end to disconnect it from Bushy Island. Whether the mean high water line is accurately delineated on this map is unknown, but at low water a prominent "tombolo" still extends to Bushy Island. This end of the beach was breached in 1938 (30) and probably by every historical storm before or since. A minor effort has been made to fortify the low section of the bar near Bushy Island with rocks. The area, a State park, and designated a Critical Erosion Area (38), might benefit from sand placement and dune management.

In Mumford Cove, the recurved spit on the east shore is indicated to have moved south 50-100 ft.; the lagoon farther SW is shown somewhat diminished in size (41).

The formation of the double tombolos at Groton Long Point (26) presents an interesting question in coastal geology. The beaches have been heavily developed residentially for several decades and the "low dunes fixed with beach grass" (26) are long gone. Efforts at stabilization, consisting mainly of seawall construction, have been successful on the tombolos (30). About 70 ft. of recent recession is indicated in the central section of the southern tombolo (41) but this is considered to be within the limits of map error and cyclical beach processes. A new lagoon to the west of the northern tombolo appears on the photorevised map (41) but does not exist at present--the older map is considered more accurate in this regard.

The west shore of Palmer Cove, consisting of bouldery till and designated a Critical Erosion Area (38) contains several groins which increase in effectiveness toward the north. The outwash shore near the east end of the highway bridge has undergone recent minor erosion which threatens to topple a tree. Accretion in the vicinity results from construction of a parking area.

MYSTIC QUADRANGLE

General

The Mystic Quadrangle resembles Branford and western Guilford Quadrangles in the great irregularity of its mainland coast and abundance of bedrock outcrops. The abundance of small marsh deposits in sheltered areas is also here, accounting for 23 miles of shoreline. A large fraction of the 12.6 miles of beach shoreline occurs on Sandy Point and Napatree Beach, the remainder consisting of small inaccessible pockets, tombolos and barrier spits. Outwash shoreline is common (about 11 miles) along backwaters across the quadrangle where, strangely, marsh has not developed. The presence of the railroad bed with its immovable tressels is perhaps most conspicuous in this quadrangle. In addition to restricting circulation, many coves and estuaries which would otherwise be suitable for marina development and associated recreational use are thus diminished in potential. The shelter offered by Fisher's Island diminishes wave energy along the coast but has not prevented drastic hurricane damage.

Discussion

The shore of Noank has a long history of modification for boat

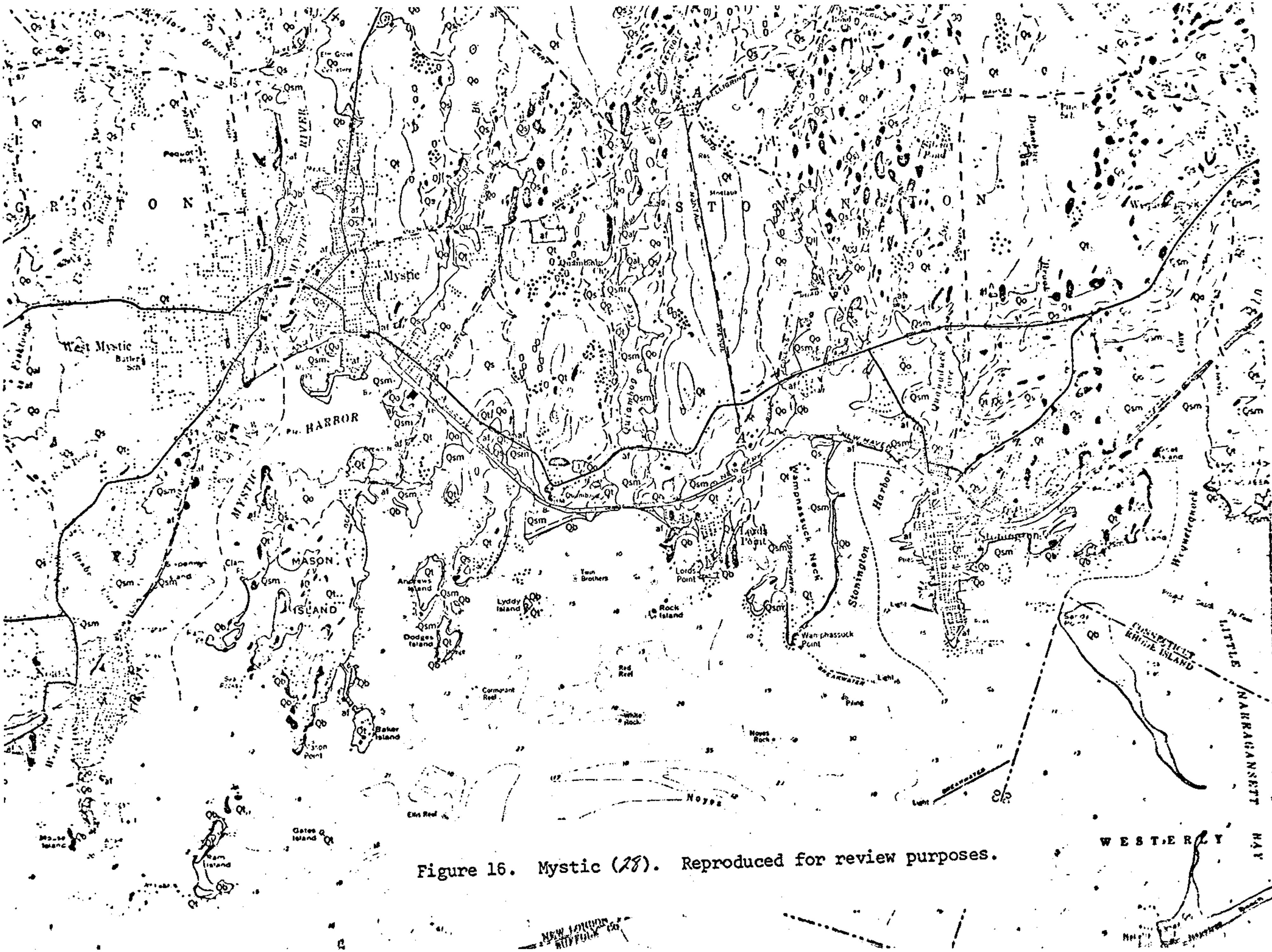


Figure 16. Mystic (28). Reproduced for review purposes.

yards, commercial and residential development. Modern piers and groins are interspersed with decrepid structures of considerable antiguity. Sixpenny Island, to the north, is a marsh island which overlies 14 ft. of peat and mud representing about 3,000 years of deposition (28). Its exposure and irregular banks would suggest rapid erosion but this has not been detectable (40). Beebe Cove and Spence Point, like Noank, are protected by old walls and riprap which have prevented natural changes with the possible exception of some enlargement of the marshes (40).

The intensely managed Mystic River shore shows many alterations in recent years with the expansion of dock facilities. Similarly, Murphy Point to the east has been artificially filled and modified.

The shoreline of Mason Island shows only minor changes on the photorevised map (40), which can be attributed to boatyard construction (SE of Pine Point) and new boat-tending facilities elsewhere. Some of the changes, implying bedrock recession, probably result from map error. Most of the shoreline remains unchanged including the cuspate beach at Clam Point which was identified as an area experiencing rapid erosion in 1929 (26). Marsh deposits have extended outward NE of Mason Point and along a section of the east shore of the Island. Small scale beach improvement efforts have been concentrated along this section (30).

The peninsula NE of Andrew's Island, called Latimer Point, has received some recent riprap protection. Minor changes in marsh configuration also occur there. The small marsh and sand point to the west, north of Lyddy Island, has shown some interesting recent changes. The area is attributed with up to 300 ft. of recession since 1838 (30) which the seaward outcrop of marsh beneath beach would suggest is continuing. However, since 1958 a vegetated barrier spit has formed across the cove while only minor marsh erosion is evident. The freshwater and tidal flow seem to have stopped spit growth leaving a 20-30 ft. inlet. No new sand sources are apparent but since recession has been possible mainly at the west end of the shoreline the resulting natural rotation of the beach could have caused an increased westward littoral drift.

The pocket beach at Lord's Point has not shown recent change (10) despite its reported history of recession (30). Erosion of a small peat covered tombolo extending toward a wreck on the east side of Wamphassuck Neck might be explained in terms of deterioration of the wreck. Artificial filling and construction explains changes on the west and south sides of Stonington Point.

Sandy Neck, a barrier island, has undergone the largest change of any part of the study area. Since 1958 its axis has rotated about 20° counterclockwise and the island has "moved" north slightly, although no great change in size has occurred. Extensive development of dunes, vegetated by grass, is limited to the northward end. Old maps show Sandy Point as a spit connected to Napatree Point forming an "L" shaped configuration; BEB maps indicate northward extension of about 1/2 mile since 1839 (37). The separation occurred during the 1938 hurricane and although it was predicted that the breachway would close naturally (22) it has continued to enlarge since then. The photorevised map (40) shows the axis of the sand spit from Napatree Point rotated clockwise and Napatree Beach moved northward more than 100 ft.

WATCH HILL QUADRANGLE

General

The study area ends at Watch Hill Point, about a mile from the west boundary of the quadrangle. The Point marks the impingement of the Charlestown end moraine on the shoreline and separates the straight sandy beaches of Rhode Island to the east from the irregular, sand-poor coast of Connecticut to the west. Less than 8 miles of shoreline are considered in this quadrangle of which all beach occurs on Napatree Beach. Peat makes up about 40% of the shoreline; most resistant features of the coast consist of till.

Discussion

Barn Island marsh is one of Bloom's study areas (6). He describes the marsh as sandy peat overlying bedrock or glacial till. Sedimentation averaged 1 mm/yr., and no erosion of the marsh edge could be determined over 4 years by detailed surveys of a relatively exposed peninsula.

Pawcatuck Point consists of till and has been stable for many years. Watch Hill Point is protected by substantial walls and boulder deposits which protect it from all but the most severe storms, which have caused severe erosion there (22,37).

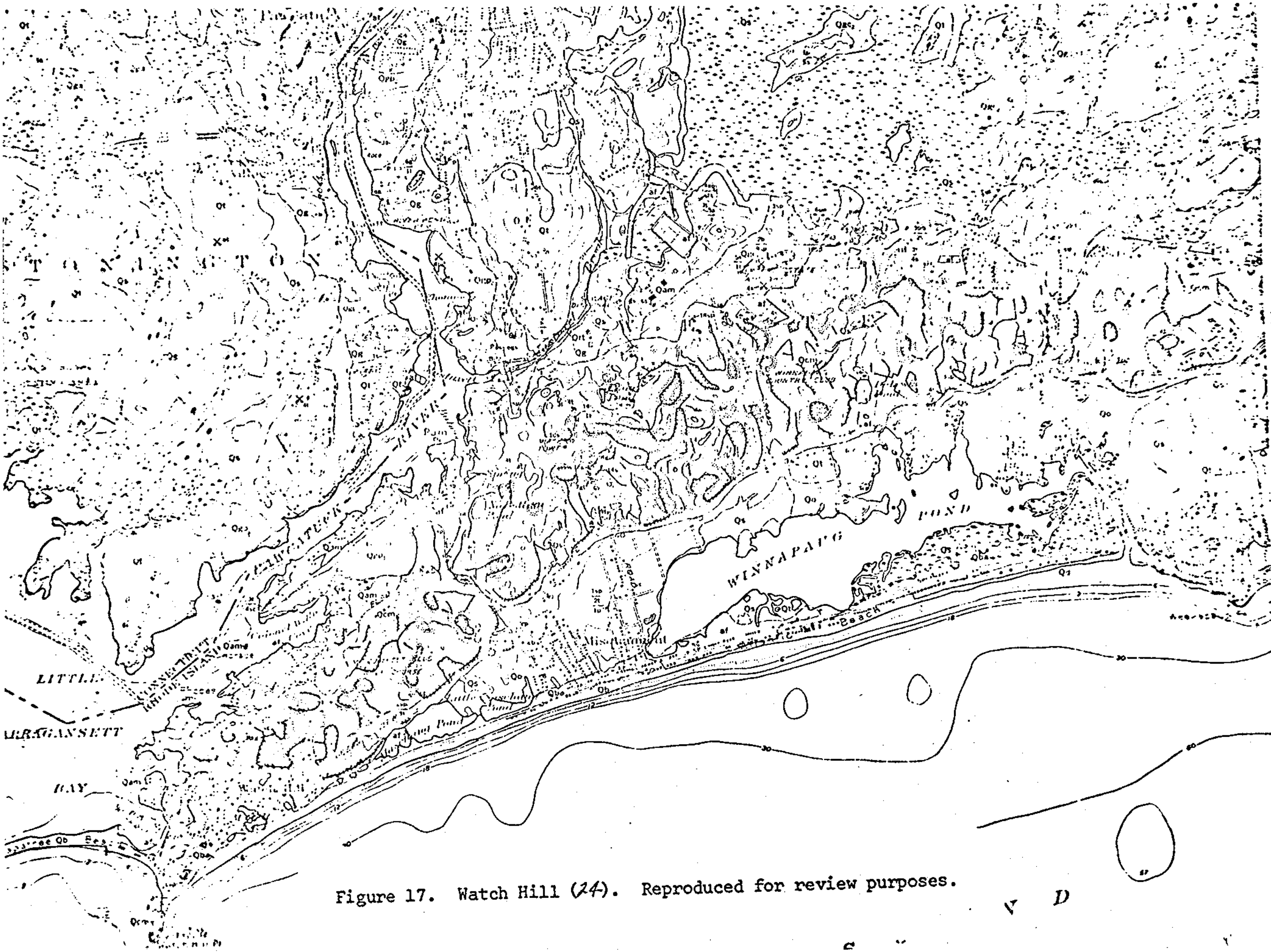


Figure 17. Watch Hill (24). Reproduced for review purposes.

CONCLUSIONS

1. Most shoreline changes over recent historical times are of the same general magnitude as map error at the 1:24,000 scale, and cannot be delineated with confidence.

2. Greatest recent changes in shoreline seem to be associated with beach and peat deposits which make up the only large shoreline segments not artificially contained behind seawalls.

3. Quantitative assessments of shoreline erosion cannot confidently be based on field spot checks; methodical detailed surveys are needed.

4. Man-made modifications account for conspicuous and appreciable shoreline changes.

5. Improvement of existing and forthcoming surficial geology maps of the coast will require mapping at a considerably larger scale with attention to man-made shoreline structures and filling activities.

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